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A

REVISION OF THE ASTACIDÆ.

By WALTER FAXON.

Part I. THE GENERA CAMBARUS AND ASTACUS.

WITH TEN PLATES.

CAMBRIDGE:
Printed for the Museum.
August, 1885.

PREFACE.

The following Revision of the crayfishes of the Northern hemisphere is based mainly upon the material in the Museum of Comparative Zoölogy. Through gifts from friends, and through a system of exchanges carried on during the past few years, the Museum now possesses all the known species of Astacus from Europe and Asia, together with all the American species of Astacus and Cambarus excepting *Cambarus angustatus* (Le Conte), *C. Wiegmanni* Erichs., and *C. Mexicanus* Erichs., and the doubtful species *C. maniculatus* (Le Conte), *C. Stygius* Bundy, *C. Nebrascensis* Girard, and *Astacus Oregonus* Randall. In this collection is included the chief part of the material used by Dr. Hagen in the preparation of his Monograph of the North American Astacidæ, a work which forms the foundation of our knowledge of the crayfishes of this continent. One may form some notion of the importance of the material received since the publication of Hagen's memoir, from the fact that twenty new species of Cambarus are made known in the following pages,* while Dr. Hagen described but ten unknown to previous authors.

Besides the collection in the Museum of Comparative Zoölogy, I have examined these:—

1. The collection in the United States National Museum at Washington. Next to that at Cambridge this is the richest collection of Astacidæ in the United States, and both have been much benefited by interchanges. All of the new material received at the National Museum during the preparation of this Revision has been promptly sent to me for study. For this invaluable aid I am under great obligation to Prof. S. F. Baird, Director of

* Since this was written, descriptions of the new species have been printed in the Proceedings of the American Academy of Arts and Sciences, Vol. XX. pp. 108–135, December, 1884. Such a course seemed desirable on account of delay in the publication of the complete memoir.

the National Museum, and to Mr. Richard Rathbun, Curator of Invertebrata. Of the types of Girard's and Stimpson's species which this collection once contained, I was able to find only two, *C. Pealei* Gir. (= *C. affinis* Say) and *A. Trowbridgii* Stm. The rest were probably lost in the great fire of Chicago in 1871, while in Stimpson's hands.

2. Through the courtesy of the Council of the Academy of Natural Sciences of Philadelphia, I have had the opportunity to inspect the Astacidæ in the collection belonging to the Academy; and the specimens that demanded more than a cursory examination have been sent to me in Cambridge. This collection, although small, is of great historical interest, since it contains many apparently authoritative examples of Girard's species, together with types of species described by Harlan, Gibbes, and Le Conte. It was examined by Hagen also in the course of the preparation of his Monograph.

3. The collection of the Peabody Museum of Yale College, New Haven, Conn., containing types of *Astacus Trowbridgii* Stimpson and *Cambarus Sloanii* Bundy.

4. The Astacidæ belonging to the Boston Society of Natural History.

5. The collection of the Peabody Academy of Science, Salem, Mass.

6. The valuable collection of Maryland and Virginia Cambari brought together by Mr. P. R. Uhler, of Baltimore, Maryland. This collection is contained in upward of one hundred and eighty jars. Through the labors of Mr. Uhler, Maryland is now one of the best explored States in the Union.

7. Prof. O. P. Hay of Butler University, Irvington, Indiana, has kindly offered for my examination an interesting collection of sixteen species of Cambarus secured in the West and South by himself and Prof. D. S. Jordan.

I take this opportunity also to acknowledge the loan of specimens from the private collections of Professors L. A. Lee, R. R. Wright, A. S. Packard, D. S. Jordan, and B. F. Koons, Dr. C. H. Merriam, and Messrs. R. S. Tarr and C. H. Gilbert.

The second part of this Revision will include the crayfishes of the Southern hemisphere, the Parastacinæ.

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A

REVISION OF THE ASTACIDÆ.

The family Astacidæ, in a strict sense, is equivalent to the genus Astacus, as limited by Milne Edwards in 1837.* Thus restricted, it includes only fresh-water species, the crayfishes proper, — animals closely related to the marine family of lobsters, or Homaridæ (Homarus, Nephrops, Nephropsis, Enoplometopus, Phoberus), from which they are distinguished by having the last segment of the thorax movably articulated with the preceding segment, and by having the podobranchiæ (or gills borne on the thoracic limbs) closely united to the epipodites (or external branches of the limbs), to the more or less complete suppression of the lamellar portion of the epipodite. On the other hand, the Astacidæ lead, through such forms as Thaumastocheles† and Calocaris, to the fossorial Thalassinidæ.

Thus limited, the Astacidæ are Macrourous Decapod Crustacea, with carapace produced into a rostrum in front, and divided by a transverse groove (cervical groove); narrow thoracic sterna; posterior thoracic somite united to the preceding somite by a movable joint; second to sixth abdominal somites with a broad descending lateral plate (pleuron) on each side, which protects the abdominal appendages; antennules terminated by two filaments; antennæ furnished with a movable external scale or squame;‡ first pair of legs much enlarged, chelate; second and third pairs of legs with small chelæ; last two pairs of legs not chelate; first pair of abdominal

* Histoire Naturelle des Crustacés, Tom. II. p. 329.

† A genus founded by Wood-Mason (Proc. Asiatic Soc. Bengal, 1874, p. 181) for the reception of *Astacus zaleucus* Willemoes-Suhm, brought up by the "Challenger" from a depth of 450 fathoms, near Sombrero Island, West Indies. See Trans. Linn. Soc. London, 2d Series, Vol. I., Zoöl., pp. 48–50, Pl. X. fig. 1. Until the structure of the gills is known, it is impossible to say whether, from the sum of its characters, Thaumastocheles should be placed among the Astacidæ or among the Thalassinidæ.

‡ The antennal scale is very small in *Astacoides Madagascariensis* Aud. et M. Edw.

appendages of male transformed into styliform organs, or else absent; external branch of posterior pair of appendages divided by a transverse suture; gills composed of a stem beset with numerous cylindrical filaments (trichobranchiæ), those borne on the proximal segments of the thoracic appendages (podobranchiæ) imperfectly, or not at all, separated into a proper branchial and a lamellar portion; just in front of the base of the podobranchiæ a pencil of long, fine setæ (coxopoditic setæ) arises from a small papilla on the proximal segment of the legs.

Huxley has shown, in his essay "On the Classification and the Distribution of the Crayfishes,"* that the family Astacidæ, as defined above, naturally falls into two subordinate groups, to which I would assign the value of subfamilies, viz.: —

1. The POTAMOBIINÆ, comprising the crayfishes of North America, Europe, and Asia. In these the first abdominal somite in the male bears a pair of styliform appendages;† the podobranchiæ borne on the second and third maxillipeds and on the first three pairs of legs are furnished with a broad bilobed plaited lamina; the epipodite of the first maxilliped is destitute of branchial filaments; the coxopoditic setæ are acute, not hooked, at the end; the telson is commonly divided more or less completely by a transverse suture.

The subfamily Potamobiinæ includes two genera: —

a. Cambarus, distinguished principally by the absence of gills on the last thoracic somite and the absence of a bilobed lamina from the podobranchiæ of the penultimate pair of legs. (Page 3.)

b. Astacus, characterized chiefly by the presence of a pair of branchiæ on the wall of the last thoracic somite, and a folded lamina on the podobranchiæ of the thoracic appendages from the second maxilliped to the penultimate pair of legs inclusive. (Page 125.)

2. The PARASTACINÆ, comprising all the crayfishes of the Southern hemisphere; viz. those of South America, Madagascar, Australia, Tasmania, New Zealand, and the Feejee Islands.‡ In this subfamily the first abdominal somite is devoid of appendages in both sexes; the podobranchiæ

* Proc. Zoölog. Soc. London, 1878, pp. 752–788.

† The first abdominal appendages are rudimentary or absent in the female.

‡ In the collection of the United States National Museum there is a specimen of an undescribed Parastacine from Colima, Mexico, collected by J. Xantus. This is the only representative of the Parastacinæ which has been found north of the equator. According to Huxley, *op. cit.*, p. 771, there are two specimens of Paranephrops from the Feejee Islands in the British Museum. Perhaps the locality labels of the Mexican and Feejee specimens are erroneous.

lack the bilobed plaited lamina of the Potamobiinæ, although the stem may be expanded into a wing; the epipodite of the first maxilliped almost always carries branchial filaments; the coxopoditic setæ terminate in hooks; the telson is not divided by a transverse suture.*

Six genera of Parastacinæ have been described; viz. *Astacoides*, by Guérin; *Cheraps* and *Engæus*, by Erichson; *Paranephrops*, by White; *Astacopsis* and *Parastacus*, by Huxley. Some of these genera are based on too trivial characters to be valid. The group will be revised in the second part of this memoir.

CAMBARUS.

In the genus Cambarus, established by Erichson in 1846,† the cephalothorax is subcylindrical. The last thoracic somite is devoid of gills, neither are there any traces of rudimentary pleurobranchiæ on the anterior somites; the hindmost podobranchia has no lamina. The branchial formula is as follows: —

Somite. ‡	Podobranchiæ.	Arthrobranchiæ.		Pleurobranchiæ.		
		Anterior.	Posterior.			
VI.	0 (ep.)	0	0	0	=	0 (ep.)
VII.	1	1	0	0	=	2
VIII.	1	1	1	0	=	3
IX.	1	1	1	0	=	3
X.	1	1	1	0	=	3
XI.	1	1	1	0	=	3
XII.	1	1	1	0	=	3
XIII.	0	0	0	0	=	0
	6 + ep.	+ 6	+ 5	+ 0	=	17 + ep.

This gives a total of thirty-four branchiæ, counting those on both sides of the thorax. The orifice of the green gland is situate near the apex of the

* Chilton (Trans. New Zealand Inst., Vol. XV. pp. 152, 163, Pl. xx. fig. 7, 1882) has observed that the internal male reproductive organs in *Paranephrops setosus* are very different from those in the Potamobiinæ. In the former the testes are two long tubes united by a transverse commissure, while in the latter they form a trilobed organ through the coalescence of the right and left testes posterior to the vasa deferentia. I have dissected an undescribed Parastacine from Chili, and find the testes to agree with those of Paranephrops. It will probably be found that all the Parastacinæ agree in this regard. On account of the resemblance of the internal male generative organs in Paranephrops and Palinurus, and the further agreement of the Parastacinæ and Palinuridæ in the absence of the first pair of abdominal appendages and presence of hooked setæ, Chilton has forced these groups into too close relationship. Cf. T. Jeffery Parker, in the same journal, Vol. XVI. p. 305.

† Uebersicht der Arten der Gattung Astacus. Arch. f. Naturgesch., XII. Jahrg., Bd. I. p. 88.

‡ The somite that bears the first pair of maxillipeds is here reckoned as the sixth.

short conical tubercle of the basal segment of the antennule. The third (in *C. Montezumæ* and *C. Shufeldtii* the second and third), or the third and fourth pairs of legs in the male, have a prominent tubercle or hook on the anterior border of the third segment. The first pair of abdominal appendages in the male are terminated by styles, hooks, or teeth.* A more or less mobile annulus is situated on the sternum of the female, just behind the penultimate thoracic somite;† and in this sex the first pair of abdominal appendages, though much smaller than the succeeding pairs, and simple, are somewhat larger than in the genus Astacus. The telson is clearly divided by a transverse suture.

The genus Cambarus is widely distributed over the North American continent, from Lake Winnipeg to Guatemala, from New Brunswick to Wyoming Territory. For a fuller account of the geographical distribution of the genus, the reader is referred to page 178.

Bibliography of the Genus Cambarus, from the Year 1868 to the Present Time.

Although seventeen years have elapsed since the genus Cambarus was revised by Dr. Hagen,‡ but little has been added to our knowledge of these animals during that period. The bibliography of the genus down to the year 1868 has been given with sufficient fulness on pages 5–12 of Hagen's memoir. I will briefly mention the works published since that date which treat of these animals.

1871. E. D. Cope, in an article entitled "Life in the Wyandotte Cave," in the Indianapolis Journal, Sept. 5 (reprinted in Ann. and Mag. of Nat. Hist., 4th Ser., Vol. VIII. pp. 368–370), records the capture of a blind crayfish in the Wyandotte Cave, Crawford Co., Ind. It is considered to be the same as the Mammoth Cave species, *C. pellucidus*.

1872. In a "Report on the Wyandotte Cave and its Fauna" (Third and Fourth Ann. Rep. Geolog. Surv. Ind., pp. 157–182; Amer. Nat., Vol. VI. pp. 406–422), Cope gives a fuller account, accompanied by a figure, of the Wyandotte Cave species, which, after comparison with *C. pellucidus*, he concludes to be a new species. This he names *Orconectes inermis*, establishing a new genus for the reception of the two blind species.

* A detailed description of these appendages will be found on page 17 of Hagen's Monograph of the North American Astacidæ.

† See Hagen, *op. cit.*, p. 19.

‡ Monograph of the North American Astacidæ, by Dr. Hermann A. Hagen. Ill. Cat. Mus Comp. Zoöl., No. III. (Mem., Vol. II. No. 1), 1870. This monograph was finished in 1868, although not published till two years later.

In the next number of the American Naturalist, Aug., 1872 (Vol. VI. p. 494), Hagen doubts the specific difference of the two cave forms, and opposes the establishment of a new genus based on the rudimentary condition of the eyes.

1872. In a memoir "Ueber Cubanische Crustaceen" (Arch. f. Naturgesch., XXXVIII. Jahrg., Bd. I. pp. 77–147), E. v. Martens describes *Cambarus Cubensis* Erichs. from Cuba, and *Cambarus Montezumæ*, var. nov. *tridens*, from Mexico. Short diagnoses of *C. Cubensis* Erichs., *C. Wiegmanni* Erichs., *C. Mexicanus* Erichs., *C. Aztecus* Sauss., and *C. Montezumæ* Sauss., are added. Concerning the identity of *C. Cubensis* Sauss. and *C. consobrinus* Sauss., Von Martens is doubtful; but he thinks it probable, from specimens sent to the Berlin Museum by Dr. Gundlach, that there is a second Cuban Cambarus agreeing with *C. Cubensis* in the shape of the rostrum, but differing from it in the sexual appendages.

1873. In a paper "On the Cave Fauna of Indiana" (Fifth Ann. Rep. Peabody Acad. Sci., Salem, pp. 93–97), A. S. Packard, Jr. communicates the results of a comparison of the blind Cambari from the Mammoth and Wyandotte Caves. He concludes that they are one and the same species, and doubts, with Hagen, the validity of a genus based on the atrophy of the visual organs.

1873. Dr. Charles C. Abbott prints, in the American Naturalist, Vol. VII. pp. 80–84, "Notes on the Habits of certain Crawfish." The observations were made at Trenton, N. J., upon three species, — "*C. acutus* Gir." (*C. Blandingii*), *C. affinis*, and *C. Bartonii*. Specimens of all three of these species, received from Dr. Abbott, are in the Museum of the Peabody Academy of Science, Salem, Mass.

1874. Prof. S. I. Smith, in a paper on the Crustacea of the Fresh Waters of the United States, in U. S. Fish Commissioner's Report for 1872 and 1873, gives a list of the Astacidæ of the Northern United States east of the Mississippi River (pp. 637–639). This list is compiled from Hagen's Monograph, but adds new localities for *C. propinquus* and *C. Bartonii*. *Orconectes inermis* Cope is considered a synonym of *Cambarus pellucidus*.

1874. In "Remarks on the Mammoth Cave and some of its Animals" (Bull. Essex Inst., Vol. VI. pp. 191–200), Mr. F. W. Putnam speaks of the association of *C. pellucidus* and *C. Bartonii* in the Mammoth Cave of Kentucky. The occurrence of *C. pellucidus* near the entrance of another cave several miles from Mammoth Cave is noted, and observations are added on the color of cave specimens of *C. pellucidus* and *C. Bartonii*.

1875. Substantially the same observations are again printed by Mr. Putnam in Proc. Boston Soc. Nat. Hist., Vol. XVII. pp. 222–225.

1875. "On some of the Habits of the Blind Crawfish, *Cambarus pellucidus*, and the Reproduction of lost Parts." By F. W. Putnam. Proc. Boston Soc. Nat. Hist., Vol. XVIII. pp. 16–19. In this communication Mr. Putnam treats of the habits, coloration, exuviation, and restoration of lost parts in *C. pellucidus* and *C. Bartonii*. The observations were made upon living specimens, brought to Cambridge, Mass., from the Mammoth Cave. The specimens are now preserved in the Museum of Comparative Zoölogy. One of the specimens of *C. pellucidus* lived upwards of nine months in confinement, exposed to the full glare of day.

1875. In an essay "On the Antiquity of the Caverns and Cavern Life of the Ohio Valley" (Mem. Boston Soc. Nat. Hist., Vol. II. p. 362; also in Mem. Ky. Geolog. Surv., Vol. I. Part 1., 1876), Professor N. S. Shaler speculates on the origin of the blind *Cambarus pellucidus* of the Mammoth Cave. (See p. 41.)

1875. Brocchi, in his "Recherches sur les Organes Génitaux Males des Crustacés Décapodes" (Ann. Sci. Nat., 6e Série, Zool. et Paléontol., Tom. II. Art. 2), figures the first

abdominal appendage of the male *Cambarus robustus* (Pl. XIII. fig. 15), and criticises Hagen for retaining the genus Cambarus as distinct from Astacus, and for dividing the genus into upwards of thirty species, based chiefly on the form of the male appendages. With regard to the first point, the generic value of Cambarus, Brocchi asserts that, of all the characters urged by Hagen as a warrant for the establishment of the genus, only one seems to him to be of any importance, namely, the absence of the posterior branchiæ, and this *he has not been able to verify!* He goes on to say (p. 26): "Si l'on prend, par exemple, le caractère tiré de la présence d'un ongle à la troisième et quatrième paire de pattes, je ferai observer qu'une seule espèce Cambarus, le *Cambarus acutus*, présente cet appendice à la troisième et quatrième paire de pattes; tous les autres ont seulement les quatrième et cinquième paires unguiculées, caractère qui leur est commun avec les Écrevisses [Astacus]." This passage is inexplicable to me, but seems to show a complete misconception of what Hagen means by the hooked legs of Cambarus. With regard to the second point, — Hagen's division of Cambarus into species, most of which, according to Brocchi, should be considered as simple varieties, — it must be admitted that there will always be a difference of opinion concerning the amount of variation necessary to warrant the erection of species; but I think that any zoölogist, with ample material before him, will admit the justice of Hagen's principle of division. Brocchi's censure of Hagen's work is wholly unmerited, and springs from ignorance of the subject under discussion. That the author does not understand the phenomenon of two forms of the male Cambari is shown on page 28. The final objection to Hagen's principle of classification, that it would lead to the breaking up of the European *Astacus fluviatilis* of authors into several species, is of no weight, since the dismemberment of that species was brought about long ago on other grounds than the character of the male appendages. Brocchi's *Astacus fluviatilis*, from Vaucluse (Pl. XII. figs. 12, 13), is *A. pallipes* Lereboullet.

1876. S. A. Forbes, in his "List of Illinois Crustacea, with Descriptions of New Species" (Bull. Ill. Mus. Nat. Hist., No. I. pp. 3–25), records, with annotations, *C. acutus* Gir., *C. virilis* Hag., *C. propinquus* Gir., *C. immunis* Hag., *C. obesus* Hag.; also, on the authority of Dr. Hagen, *C. troglodytes* and *C. placidus*. The second form of the male *C. immunis* Hag. is described for the first time. Three new species, described by W. F. Bundy, are included in the list: *C. Stygius*, from Lake Michigan; *C. Wisconsinensis*, from Normal, Ill., and Racine, Wis.; and *C. gracilis* from Illinois and Wisconsin. In an appendix to the list, Mr. Bundy describes two more new species of Cambarus from without the limits of the State of Illinois; viz. *C. Sloanii* from Southern Indiana and Kentucky, and *C. debilis* from Wisconsin.

Of Bundy's species I have seen types (in the Museum of Comparative Zoölogy) of *C. Wisconsinensis*, *C. gracilis*, *C. Sloanii*, and *C. debilis*. *C. gracilis* and *C. Sloanii* are good species. *C. Wisconsinensis* appears to be the same species as Hagen's *C. placidus* (= *C. rusticus*, var. ?). *C. debilis* is the second form of the male of *C. virilis* Hag. *C. Stygius*, according to Bundy in a later paper, closely resembles *C. acutus*, but differs in the shorter chelæ, which resemble those of *C. propinquus*. All of the specimens of this species seen by Bundy were mutilated, the fourth pair of legs being lost.

1877. Mr. Bundy ("On the Cambari of Northern Indiana," in Proc. Acad. Nat. Sci. Phila., 1877, pp. 171–174) records *C. immunis* Hag., *C. obesus* Hag., *C. virilis* Hag., and *C. propinquus* Gir., from Northern Indiana; redescribes *C. Sloanii* from Southern Indiana and Kentucky; and describes a new species, *C. spinosus*, from near Rome, Georgia. Through the courtesy of Mr. P. R. Uhler, the Museum of Comparative

Zoölogy has obtained types of *C. spinosus*. It is a distinct species from any previously described.

1877. Dr. Thomas H. Streets, in an article entitled "Description of *Cambarus Couesi*, a new species of Crawfish from Dakota," in Bull. U. S. Geolog. and Geograph. Surv. Terr., Vol. III. pp. 803, 804, describes *C. Couesi*, sp. nov., from the Red River of the North, and gives a note (by Dr. Coues) on the color of living *C. virilis*. Types of *C. Couesi* have been received by the Museum of Comparative Zoölogy in exchange with the U. S. National Museum. They are not specifically distinct from *C. virilis*, agreeing fully with some of Hagen's types of that species.

1878. Huxley, in his essay "On the Classification and the Distribution of the Crayfishes," Proc. Zoölog. Soc. London, 1878, pp. 752–788, gives an account of the branchiæ in a species of Cambarus obtained near Coban, Vera Paz, Guatemala, at an elevation of about 4,300 feet above the sea. In his subsequent work, "The Crayfish," 1880, Professor Huxley gives a figure of the penultimate leg of this Cambarus. It is hooked as in the species of the *C. Blandingii* group. Perhaps it is *C. Wiegmanni* Erichs. The locality is interesting as being the most southern on record for the genus Cambarus.

1880–82. In the 57th Jahresbericht der Schles. Gesellsch. f. vaterl. Cultur, p. 202 (1879), it is recorded that Dr. Gustav Joseph exhibited a blind Cambarus, *C. typhlobius*, sp. nov., from the caves of Carniola, closely related to *C. pellucidus* from the Mammoth Cave, Kentucky. In a paper published in December, 1881, in the twenty-fifth volume of the Berliner Entomologische Zeitschr., the same writer again mentions the blind Crayfish by the name *Cambarus cæcus*, sp. nov. (p. 237), and *Cambarus Stygius*, sp. nov. (p. 249). In the twenty-sixth volume of the same journal, p. 12, April, 1882, Dr. Joseph gives a fuller account of this species under the name *Cambarus Stygius*. (See p. 45 of this Revision.)

1881. A new blind Crayfish from the Nickajack Cave, Tennessee, is described and figured by Cope and Packard in the American Naturalist, Vol. XV. pp. 877–882, Pl. VII. ("The Fauna of the Nickajack Cave"). This species is named *Orconectes hamulatus*. It resembles *C. pellucidus* in general form, but the external sexual parts are similar to those of the Cambari belonging to the *C. Bartonii* group. The authors surmise that *O. hamulatus* is derived from *C. latimanus*. Two type specimens have been presented to the Museum of Comparative Zoölogy by Professor Packard.

1882. Mr. C. L. Herrick, in the Tenth Ann. Rep. Geolog. and Nat. Hist. Surv. of Minnesota, pp. 253, 254, records *Cambarus virilis* Hagen from Minnesota, and describes as a new species *C. signifer*, from Hennepin County, in the same State. Types of both of Herrick's species have been procured through the U. S. National Museum and Mr. Herrick. The "new" species, *C. signifer*, does not differ from Hagen's *C. immunis* enough to be esteemed a different species, as was pointed out in Science, Vol. I. p. 15, 1883.

1882. "A List of the Crustacea of Wisconsin, with Notes on some new or little known Species," by W. F. Bundy, in Trans. Wis. Acad. Sci., Arts, and Letters, Vol. V. pp. 177–184. In this paper *C. Stygius*, *C. Wisconsinensis*, *C. debilis*, and *C. gracilis*, all of them Bundy's species, are again described. *C. acutus* Gir., *C. virilis* Hag., *C. propinquus* Gir., *C. placidus* Hag., *C. rusticus* Gir., *C. obesus* Hag., and *C. Bartonii* Erichs., are also included in the list as Wisconsin species, *C. rusticus* and *C. Bartonii* from Lake Superior.

1883. "The Crustacean Fauna of Wisconsin, with Descriptions of little known Species of Cambarus," by W. F. Bundy, in Geology of Wisconsin, Survey of 1873–79,

Vol. I. pp. 402–405. This paper is the same in substance as the last; but *C. placidus* Hag. is omitted from the list, and *C. Couesi* Streets ? is added.

1883. The exhibition of living specimens of *Cambarus Bartonii* from North Grafton, Worcester Co., Mass., at the rooms of the Worcester Natural History Society, is recorded in "Scientific and Literary Gossip," Vol. I. p. 113. The only locality in this State hitherto known was Williamstown, in Berkshire Co. Through the kindness of Mr. F. G. Sanborn these specimens are now in the collection of the Museum of Comparative Zoölogy.

1884. In a note "On the so-called Dimorphism in the Genus Cambarus," in Amer. Journ. Sci., Vol. XXVII. pp. 42–44 (reprinted in Ann. and Mag. of Nat. Hist., 5th Ser. Vol. XIII. pp. 147, 148), I suggested that the two forms of the male Cambarus were alternating conditions of the same individual connected with the reproductive seasons, and not dimorphic forms, as was commonly supposed. (See p. 12.)

1884. Mr. Ralph S. Tarr describes in Nature, Vol. XXX. pp. 127, 128, the burrows of *C. Diogenes* Girard.

1884. Dr. C C. Abbott, in the American Naturalist, Vol. XVIII. pp. 1157, 1158, takes exception to Mr. Tarr's conclusion that the mud chimneys built by *C. Diogenes* are the accidental result of the excavation of the burrows.

1884. Descriptions of the new species of Cambarus found during the preparation of this Revision, together with a synonymical list of the species of Cambarus and Astacus, were published by me in the Proceedings of the American Academy of Arts and Sciences, Vol. XX. pp. 107–158, December, 1884.

Dr. Hagen's Monograph must ever remain the foundation for all systematic work on the North American Astacidæ. The types of all his species are in the Museum of Comparative Zoölogy, and have been constantly before me in the preparation of the present Revision. With far ampler material at my disposal than fell to Dr. Hagen's lot, I have seldom had occasion to differ from him in his conclusions concerning the species known to him. Thirty-two species of Cambarus are described by Dr. Hagen. Of these, eleven are described as new species; viz. *C. fallax*, *Lecontei*, *versutus*, *lucifer*, *virilis*, *placidus*, *juvenilis*, *obscurus*, *immunis*, *extraneus*, and *obesus*. Of these, *C. placidus* and *C. juvenilis* are in my opinion only forms of the variable species *C. rusticus* Gir.; *C. obscurus*, a local variety of *C. propinquus* Gir. *C. obesus* is the same as *C. Diogenes* Gir. The remaining species included in Hagen's memoir are *C. acutus* Gir., *Clarkii* Gir., *troglodytes* (LeC.), *Blandingii* (Harlan), *spiculifer* (LeC.), *angustatus* (LeC.), *maniculatus* (LeC.), *penicillatus* (LeC.), *Wiegmanni* Erichs., *pellucidus* (Tellk.), *affinis* (Say), *propinquus* Gir., *rusticus* Gir., *Bartonii* (Fab.), *robustus* Gir., *Nebrascensis* Gir., *latimanus* (LeC.), *Mexicanus* Erichs., *Cubensis* Erichs., *advena* (LeC.), and *Carolinus* Erichs. *C. maniculatus*, *Nebrascensis*, *Mexicanus*, and *Cubensis* were known to Hagen only through the descriptions of the original authors of the species. *C. acu-*

tus Gir. I consider to be the Southern and Western form of *C. Blandingii* Harlan (= *C. acutus*, var. B, Hagen); *C. robustus*, a variety of *C. Bartonii*. By some error the descriptions of *C. advena* and *C. Carolinus* are transposed in Hagen's Monograph.

It is exceedingly difficult to discriminate between the different species of North American Cambari, even with the help of the most careful descriptions and figures, which are rarely afforded us by the older authors. It therefore becomes a matter of the first importance to examine type specimens whenever it is possible. In September, 1870, Dr. Hagen examined the types of some of Erichson's and De Saussure's Cambari in the Berlin Museum, and has kindly placed in my hands the notes which he took concerning them. Of Erichson's types he found the following: — *C. pellucidus*, a male, form I. *C. affinis*, a female from Carolina, collected by Dr. Cabanis. The locality is new. Cabanis informed Dr. Hagen that all the Cambari which he collected were taken in a rivulet in the northern part of South Carolina, near Greenville, at a farm called Tiger Hall. I suspect that this specimen may be the nearly related species *C. spinosus* Bundy. (See p. 87.) *C. Bartonii*: "Erichson's types are a male, form II., and young female from South Carolina, Cabanis, and, so far as I saw, both are the young of *C. latimanus*." *C. Cubensis*: "Three males, form I., and two females, agreeing with Erichson's description. It belongs probably to Group II." (See p. 51.) *C. Carolinus*: "Erichson's type, from South Carolina, Cabanis, is a male form I., and, so far as I saw, my *C. Bartonii*." Nevertheless, Erichson's description accords well with Hagen's *C. Carolinus*. (See p. 56.) The types of Erichson's two Mexican species, *C. Wiegmanni* and *C. Mexicanus*, could not be found in the Berlin Museum by Dr. Hagen, nor at a later day by Von Martens (Arch. f. Naturgesch., 1872).

The types of De Saussure's species, *C. consobrinus* from Cuba, *C. Azteeus* and *C. Montezumæ* from Mexico, were also examined by Hagen in Berlin. When the Monograph of the North American Astacidæ was written, Hagen had seen no specimens from Cuba or Mexico, and he fell into the error of supposing that the peculiar species *C. Montezumæ* was the same as Erichson's *C. Mexicanus*. This mistake was rectified on seeing Saussure's types. *C. consobrinus*: "Saussure's types, two females, dry. A peculiar species, or a young state of *C. Cubensis*. Rostrum bidentate." *C. Azteeus*: Saussure's types. The male, first form, and female, from Mexico, seem to be *C. Mexicanus* Erichs., with nearly cylindrical hands. The second form, with more

flattened hands, belongs alone, then, to Saussure's *C. Azteeus*. In the second form the antennal scale is more broadly truncate at the end, and the rostrum is a little different. These differences are not striking enough, however, to preclude the specific identity of the two forms.

Of the species of Cambarus described by American authors before the date of Hagen's Monograph, but few types are extant. The oldest known to me are Harlan's, 1830, 1835 (*A. Blandingii* Har., *A. Bartonii* Fab., *A. affinis* Say), preserved in the collection of the Academy of Natural Sciences of Philadelphia.

In 1850, Professor Lewis R. Gibbes enumerated, without describing, four species of Cambarus under the names *Astacus Bartonii* Fab., *A. affinis* Say, *A. Blandingii* Harlan, and *A. pellucidus* Tellk. Several specimens labelled by Gibbes in the collection of the Philadelphia Academy and in the Museum of Comparative Zoölogy prove that his identifications were often incorrect, and consequently the localities given by him cannot be taken as authoritative. Under the name of *A. Bartonii* Gibbes appears to have confounded three distinct species: *C. Bartonii* (Fab.), *C. latimanus* LeC., and *C. rusticus* Gir. (See p. 65.) The localities South Carolina and Alabama cited by Gibbes under *A. Bartonii* probably refer to *C. latimanus*. Gibbes's *A. affinis* is the true *A. affinis* of Say, as is shown by a specimen in the Philadelphia Academy's collection; but the locality, "Florida," attributed to this species in Gibbes's paper, undoubtedly belongs to some other species. A specimen in the Museum of Comparative Zoölogy, determined as *A. Blandingii* by Gibbes, is *C. troglodytes* (LeC.); and to this species Gibbes's habitat, "the low country of South Carolina," properly appertains

Girard in his Revision of the North American Astacidæ (Proc. Acad. Nat. Sci. Phila., 1852) enumerates twenty species of Cambarus, twelve of which are new. The diagnoses are in many cases insufficient for the identification of the species, and it therefore becomes highly important to fix the species through an examination of typical specimens. Two of the species in Girard's list, *C. fossor* (Raf.) and *C. Oregonus* (Randall), were unknown to Girard, and remain doubtful to the present day. *C. Gambelii* (types in the Philadelphia Academy) is an Astacus. The types of most of Girard's species were formerly in the collection of the Smithsonian Institution at Washington, whence they were transported by Dr. Stimpson to the Chicago Academy of Science, and there consumed in the great fire of 1871. Fortunately, before their destruction types of five of the eleven new Cambari and two

of the previously described species were examined by Dr. Hagen in the course of the preparation of his monograph; viz. *C. Clarkii* Gir., *C. propinquus* Gir., *C. montanus* Gir., *C. rusticus* Gir., *C. longulus* Gir., *C. Bartonii* (Fab.), and *C. affinis* (Say). Hagen proved the correctness of Girard's determination of Fabricius's and Say's species. Of Girard's new species, *C. montanus* appeared identical with *C. Bartonii*, and *C. longulus* was deemed by Hagen to be an accidental variety of *C. Bartonii*. A thorough search for Girard's types in the Smithsonian Institution made by myself in December, 1882, discovered one more species, *C. Pealei*, which proved to be large specimens, male and female, of *C. affinis* (Say). These (and *Astacus Gambelii* in the Philadelphia collection) are the only types of Girard's species now existing.

There are, however, in the Museum of the Academy of Natural Sciences of Philadelphia eight species labelled with Girard's names (followed in most cases by a question-mark) *and the localities quoted by Girard.* These specimens may be considered of almost equal authority with type specimens. They are the following: *C. Pealei? C. rusticus? C. montanus? C. propinquus? C. acutissimus? C. Diogenes? C. robustus*, and *C. Blandingii*. *C. Pealei?* is the same as the typical *C. Pealei* in the Smithsonian Institution (= *C. affinis*). *C. rusticus?* and *C. montanus?* are identical with the types of the same name examined by Hagen. "*C. propinquus?* Garrison's Creek, Sackett's Harbor," is *C. obesus* Hag., and "*C. Diogenes?* District of Columbia," is *C. propinquus* as determined from the type examined by Hagen. That an accidental transposition of labels has here taken place is evident from the localities given on the labels (*C. propinquus* is not found in the District of Columbia), and from the account of the characteristic habits and coloration of *C. Diogenes* given by Girard. Through this misplacement of labels, and through his ignorance of the peculiar habits of the "chimney crayfish," Hagen failed to see the identity of his own *C. obesus* and Girard's *C. Diogenes*. *C. acutissimus?* is the young of *C. acutus*; *C. robustus* may be considered a variety of *C. Bartonii*; *C. Blandingii* is not Harlan's species, but the one afterwards described by Le Conte as *A. troglodytes*. There remain in Girard's list, to be determined without the aid of types or authoritative specimens, the following: *C. acutus* Gir., *C. pellucidus* (Tellk.), *C. Carolinus* Erichs., *C. pusillus* (Raf.), *C. Nebrascensis* Gir. *C. pusillus*, whether it be the same as Rafinesque's species or no, is probably a small form of *C. Bartonii*; *C. Nebrascensis*, I think, may be a variety of *C. Diogenes*.

Types of six of Le Conte's species (described in 1855) are preserved in the Academy of Natural Sciences of Philadelphia: *A. troglodytes*, *A. spiculifer*, *A. fossarum*, *A. angustatus*, *A. latimanus*, and *A. advena*. The Museum of Comparative Zoölogy also possesses types of *A. troglodytes*, *A. spiculifer*, *A. fossarum*, *A. latimanus*, and *A. advena*. *A. fossarum* is not separable from *A. troglodytes*. Le Conte's *A. maniculatus* remains yet unknown. (See p. 29.)

The Two Forms of the Males. — In every species of Cambarus, of which many specimens have been examined, two forms of the adult male have been found, characterized by striking differences in the conformation of the sexual parts. In the form called the first by Dr. Hagen, the external organs peculiar to the male are more perfectly formed than in the "second form," where they have somewhat the shape seen in the young male. The peculiarities of each of these forms have been fully described by Hagen,* to whose monograph the reader is referred for details. No intermediate conditions between these two forms exist, and there is no fixed relation between them and the size of the individual, males of the second form being often larger than those of the first, or *vice versa*. They cannot, then, be considered developmental stages. Dr. Hagen interpreted the facts as a case of dimorphism, and surmised that the second form males were sterile individuals; but I have since shown that males of the first form after the breeding season may revert to the second form by moulting.† The two forms of the male Cambarus, instead of being dimorphic forms, are probably alternating conditions in the life of one individual, the first form being assumed during the pairing season, the second form during the interval between the pairing seasons. The second form is probably impotent; the testes are smaller than in the first form, the vasa deferentia shorter,‡ but I have had no opportunity as yet to examine their microscopic structure.

Indications of Hermaphroditism in Cambarus. — Perhaps the only recorded case of undoubted hermaphroditism in the Decapod Crustacea is that of the lobster (*Homarus vulgaris*) described and figured by F. Nicholls in 1730.§ In

* Pages 21, 22.

† On the So-called Dimorphism in the Genus Cambarus, by Walter Faxon. Amer. Jour. Sci., Vol. XXVII. pp. 42–44, January, 1884.

‡ See Hagen's Plate II.

§ An Account of the Hermaphroditic Lobster presented to the Royal Society by Mr. Fisher, examined and dissected, by F. Nicholls. Philosoph. Trans. Roy. Soc. London, Vol. XXXVI. No. 413, p. 290, 1730 (Abridgment, Vol. VII. Pt. III. p. 121, Pl. IV., 1731). For a general account of hermaphroditic and other anomalous conditions among the Crustacea, see Faxon, On Some Crustacean Deformities, Bull. Mus. Comp. Zool., Vol. VIII. No. 13, 1881

this specimen the right half of the body was female, the left half male, as regards both internal and external organs.

Von Martens* has given an account of three specimens of a Cheraps with openings in the basal segment of the third pair of legs (the position of the sexual apertures of the normal female) co-existing with the male orifices in the first segment of the fifth pair of legs. No ovary or duct leading to the openings in the third pair of legs was detected; but as the specimens had lain in alcohol some seven years, the evidence against the existence of any internal female organs cannot be taken as positive. Similar openings were seen also in the third pair of legs of male *Parastacus pilimanus* and *P. Brasiliensis*.†

Among the vast number of Astacidæ that passed through my hands in the preparation of this memoir, I have noted four specimens, all of them Cambari, that combine external structures of the two sexes.

The first is a specimen of *C. propinquus*, var. *Sanbornii* Faxon, 60 millimeters long (M. C. Z., No. 3350). The general shape of the body with its broad abdomen, and the form of the claw, are as in the female; there are no hooks on the third pair of legs; the appendages of the first and second abdominal somites agree with those of the female, and there is a well-formed, though not prominent, annulus ventralis; the external opening of the generative system, on the contrary, is situated upon a small papilla at the base of the fifth pair of legs, exactly as in the male sex.

The second specimen also belongs to *C. propinquus*, var. *Sanbornii*. It is a young specimen, only 38 millimeters in length (M. C. Z., No. 3588). The first abdominal appendages are formed as in all young males of this species, but the sexual apertures are situate on the basal segment of the third pair of legs, and have the same appearance as in the normal female; there is also a well-formed annulus ventralis, and there are no tubercles on the third segment of the third pair of legs. The second pair of abdominal appendages are not at all transformed, but agree with the same appendages of the normal female.

The third specimen is a *C. Diogenes* Girard, from New Orleans, La., 84 millimeters long (M. C. Z., No. 242). It has all the external characters of the female, excepting the first pair of abdominal appendages, which are

* Sitzungsber. Gesellsch. naturforsch. Freunde zu Berlin, 18 Jan., 1870.

† E. Rousseau and E. Desmarest (Ann. Soc. Ent. de France, 2e Séric, Tom. VI. p. 479, Pl. XIII., Tom. VI. p. 481, 1848) have recorded cases of *Astacus fluviatilis* with two pairs of sexual orifices, one on the third, the other on the fourth pair of legs; but in these specimens both pairs of orifices were vulvæ leading to the ovaries by a branched duct on each side of the body.

curiously modified so as to resemble the same parts in the males of the genus Astacus. The transverse suture near the base of the appendage is obliterated; the apical half, instead of being membranous and fringed with setæ, as in the normal female, is firm and naked, and rolled from the outside inward so as to form on the inner side a groove which is converted into a tube just at the tip, owing to the closeness of the coil at that point. The whole organ is larger and thicker than in the ordinary female, although not so large as in the male. The tip is altogether destitute of the recurved hooks of the normal male organ in this species.

The fourth specimen belongs to *C. propinquus* Girard. It is 72 millimeters long (M. C. Z., No. 3432). It agrees with the female in every respect except the shape of the first pair of abdominal limbs, which are partly transformed into the condition which obtains in the male. The modification of the appendages has not gone so far on the right side as on the left. In both, the transverse suture is obliterated; the basal half is thick and corneous, and produced into a prominent tubercle on the inner side, as in the male. The apical half of the right appendage retains the membranaceous and setiferous character of the female appendage, while in the left it is more corneous, and rolled from without inwards in such a fashion as to form an inner and an outer part somewhat as in the male, though neither part is in this case produced into an acute style, as in the normal male, and the outer part retains the membranaceous setiferous tip.

These specimens are in such a bad state of preservation that a determination of the sex from the internal generative organs in several of them is wellnigh impossible. Dissection of the first-described specimen, with the orifices of the generative organs in the base of the last pair of legs, as in the male, revealed many large ovarian eggs, and I little doubt that the other three individuals are females which have assumed some of the characters of the opposite sex.* It would be interesting to determine from fresh specimens whether such monstrous conditions as those just described ever denote true hermaphrodites, producing both male and female generative elements, or whether they may involve sterility. They are the more interesting from the fact that hermaphroditism exists as a normal condition in another highly specialized order of Crustacea, the Isopoda.†

* Boas (Vidensk. Selsk. Skr. 6te Raekke, naturvidensk. og Math. Afd., Bd. I. pp. 94, 184) says he has seen a female *Thalassina anomala* and a female *Astacus fluviatilis* with abdominal appendages like the male, but gives no particulars concerning these specimens.

† See Bullar, Journ. Anat. Physiol., Vol. XI. p. 118, 1876; Ann. Mag. Nat. Hist., 4th Ser., Vol. XIX. p. 254, 1877; and P. Mayer, Mitth. Zoolog. Station zu Neapel, Vol. I. pp. 165, 177, 1878.

Peculiarities of the Young Stages of Cambarus. — The young Cambarus, like the young Astacus, when it leaves the egg is devoid of appendages on the first and sixth abdominal somites. The telson is not divided by a transverse suture. I have examined specimens of *C. rusticus* when but four millimeters in length, evidently just released from the egg. They have much the same appearance as the embryo of *Astacus fluviatilis* just before hatching, as figured by Rathke.* The cephalothorax is very large in proportion to the abdomen, and spherical; the rostrum is bent down between the eyes; the antennæ are laid back closely upon the breast. All of the appendages are soft, weak, and flexed beneath the sternum. There is no vestige of a gill on the last thoracic somite any more than in the adult Cambarus. The telson is a thick oval plate, entirely destitute of marginal setæ, such as are seen fringing the telson in recently hatched young of Astacus figured by Huxley on page 220 of "The Crayfish"; agreeing in this respect with the telson of the embryo of Astacus as shown in Plate II. fig. 25, of Rathke's memoir. I have no doubt that the newly hatched young of Astacus figured by Huxley has undergone one ecdysis since leaving the egg, whereby the embryonic cuticle has been discarded.

Young specimens of *C. Clarkii*, seven millimeters long, taken from under the abdomen of the parent, have acquired the general form of the adult. The swimmerets, or posterior abdominal appendages, are well developed, while in the European *Astacus pallipes*, ten days old and eleven millimeters in length, these appendages are enclosed within the notched telson, from which they are set free after the second or third moult, judging from specimens received from the Collége de France. Specimens of *C. gracilis*, nine millimeters long, and *C. Bartonii*, ten millimeters long, still under the protection of the parent, have the swimmerets perfectly expanded, and even show the transverse suture of the telson. It seems probable, from a comparison of these Cambari with the young of European Astaci, that the development of the former goes on more rapidly after leaving the egg than that of the latter.

It is interesting to observe that in the young *C. Clarkii* above mentioned the areola is moderately wide in the middle, where it is reduced to a line in the adult; the lateral spines of the rostrum are well developed, the acumen long and acute. In all the recently hatched Cambari which I have seen, the legs and claws are long and slender compared with the adult.

* Untersuchungen über die Bildung und Entwickelung des Flusskrebses, Tab. I. fig. 16, Tab. II. fig. 25.

It has been noted already that in the young stages of Cambarus and Astacus the first abdominal appendages are wanting, and the telson is not divided by a transverse suture. In these respects the young stages agree with the adult condition of the Parastacinæ. On this account, and on account of the more generalized arrangement of the gills in the Parastacinæ,* it would seem that the Potamobiinæ are a more specialized type than the Parastacinæ. Further, among the Potamobiine crayfishes the genus Cambarus will hold the highest place by reason of the complete suppression of the pleurobranchiæ and the high degree of specialization exhibited in the first abdominal appendages and hooked thoracic legs of the males and the annulus ventralis of the female. In the abnormal female of *Cambarus Diogenes*, noticed on page 13, it is clearly demonstrated that an organ essentially like the first abdominal appendage of Astacus is the first step in the transformation of the common type of abdominal limb into the male appendage of Cambarus. The three species of Cambaroides (p. 126) form a passage from Cambarus to Astacus proper.

Division of the Species of Cambarus into Subordinate Groups. — Girard divided the Cambari into three groups, based upon the form of the rostrum and the anterior pair of abdominal legs in the male. Dr. Hagen also concluded that the genus comprehended three well-defined groups, but he based his division of the genus upon the number of hooked thoracic legs in the male, taken in connection with the shape of the rostrum (whether toothed or toothless). It follows that the groups of these authors do not exactly coincide; e. g. *C. pellucidus* falls into the same assemblage of species with *C. affinis*, *C. rusticus*, etc., in Girard's system, whereas by Hagen's mode of division it is associated with *C. Blandingii* and allied species. It seems to me that we get a more natural grouping of the species by taking the number of hooked thoracic legs in connection with the structure of the first pair of abdominal appendages of the male as the basis for the division of the genus, without reference to the form of the rostrum. Any division based wholly or in part upon the presence or absence of lateral rostral spines will divorce species which in the totality of their organization are most closely related. If it be urged against this mode of division that it implies a knowledge of the peculiarities of one sex, I reply that the same objection applies to the groups of Girard and Hagen, which are based in part upon characters found only in

* In all the Parastacinæ, except *Astacoides Madagascariensis*, there are four pleurobranchiæ developed, and the whole number of gills is twenty or twenty-one.

the male. If the reader is unable to determine the group to which the specimens in his hands belong, through the lack of males, the fault lies, as Dr. Hagen observes, not in the principle of classification, but in the scantiness of his material. A species involves two sexes; and until the species is known, it avails little to attempt the determination of a specimen in this difficult genus.

In accordance with the above principle of division, the genus Cambarus falls into five subordinate groups, viz.: —

I. Third segment of third and fourth pairs of legs of male hooked. First pair of abdominal appendages of male with outer part truncate at the tip, with one to three recurved teeth; inner part terminated by a short acute spine, which is generally directed outwards. Type, *C. Blandingii*.

II. Third segment of third pair of legs of male hooked. First pair of abdominal appendages of male as in Group I. Type, *C. advena*.

III. Third segment of third pair of legs of male hooked. First pair of abdominal appendages of the male thick, terminated by two recurved teeth, the larger of which is formed by the tip of the outer part of the appendage, the smaller by the inner part. Type, *C. Bartonii*.

IV. Third segment of third pair of legs of male hooked. First abdominal appendages of male terminating in two elongated, nearly straight, acute tips. Type, *C. affinis*.

V. Third segment of second and third pairs of legs of male hooked. Type, *C. Montezuma*.

GROUP I. (Type, C. Blandingii.)

Third segment of third and fourth pairs of legs of male hooked. First pair of abdominal appendages of male with outer part truncate at the tip, and furnished with one to three small recurved teeth; inner part terminated by a short acute spine, which is generally directed outwards.

In this group the rostrum is generally triangular, with a small tooth on each side, near the apex; in *C. Lecontei*, *C. spiculifer*, *C. versutus*, and *C. pubescens*, the lateral teeth are more strongly developed. The chelæ are slender and covered with flattened, squamous tubercles, ciliated in front. The male appendages are tipped with two or three small curved teeth (corneous in the first form), and armed on the inside with a sharp spine directed obliquely or horizontally outwards. The terminal teeth are very minute in *C. fallax*.

The section of the carapace behind the cervical groove is more than half as long as the distance from the cervical groove to the tip of the rostrum, as in *C. Blandingii*, etc., or much less than half this distance, as in *C. versutus*, etc. In *C. spiculifer*, *C. versutus*, and *C. pubescens*, the areola is broad, as in the genus Astacus. In the majority of the species of Cambarus the areola is narrow, or even obliterated by the close approximation of the branchio-cardiac lines in the median line of the back, as in *C. Diogenes*, *C. Clarkii*, etc. The narrowing of the areola involves an increase in height of the branchial chambers, for the so-called branchio-cardiac lines which form the lateral boundaries of the areola denote the upper limit of the branchial chamber where the lining membrane of the carapace is continued into the lateral wall of the thorax. This increase in the height of the branchial chamber which generally obtains in the genus Cambarus may perhaps be explained as a means to allow an increase in the length of the branchiæ in compensation for the diminution in number. The broad areola which accompanies the more generalized gill formula of Astacus may be considered the more primitive form. In accordance with this view, it appears that in species of Cambarus with very narrow or linear areola, as *C. Clarkii*, the very young stages of growth display an appreciably wider areola.

The antennal scale in the species of Cambarus belonging to the first group is commonly broadest toward the base or at the middle.

The most aberrant species of the group are *C. penicillatus*, *C. Alleni*, and *C. pellucidus*. In *C. penicillatus* and *C. Alleni* the rostrum is devoid of lateral teeth, the spine that terminates the inner part of the first abdominal appendages of the male is long and erect, the terminal teeth minute. In *C. penicillatus* the antennal lamina is short, and broad toward the tip. The blind *C. pellucidus*, from the caves of Kentucky and Indiana, is the most peculiar species of the group. The sides of the rostrum are sub-parallel from the base to the lateral spines, the acumen long; the antennal scales are broadest at the distal end; the portion of the carapace which lies in front of the cervical groove is very short compared with the hinder section. The first pair of abdominal appendages of the male are hardly specialized to a greater degree than in the genus Astacus, the tips of the organs being simply produced into two small processes, the one representing the spine that terminates the inner part of the appendage in the more normal species of the group, the other the teeth of the outer part. In the first form of the male the latter process is corneous. The appendage, as a whole, is more closely rolled than

in the genus Astacus, and in its general form agrees with the corresponding limb in the other Cambari. Remarks on the relations of this interesting species will be found on page 42.

I am disposed to regard the Cambari of this group as, on the whole, the lowest forms in the genus. The slight degree of specialization of the external male appendages, the tendency toward an oval, astacoid form of body, the slender claws and generally toothed rostrum, all point to this. That the stout-clawed species with toothless rostrum are derived from forms with slender chelæ and toothed rostra seems probable from the fact that the latter characters are commonly found in very young individuals of all species.

This group corresponds exactly with Group I. of Hagen's Monograph.

- Rostrum toothed.
  - Section of the carapace behind cervical groove long (see p. 18).
    - Epistoma rounded in front: *C. Blandingii, C. Hayi, C. fallax.**
    - Epistoma truncate: *C. Clarkii, C. troglodytes.*
  - Posterior section of carapace short (see p. 18).
    - Areola narrow: *C. Lecontei.*
    - Areola wide: *C. spiculifer, C. versutus, C. angustatus, C. pubescens.*
  - Eyes atrophied: *C. pellucidus.*
- Rostrum toothless. *C. Wiegmanni, C. penicillatus, C. Alleni.*

1. Cambarus Blandingii.

Plate VII. figs. 2, 2, 2', 2 a, 2 a (first abdominal appendages of male).

Astacus Blandingii, Harlan, Trans. Amer. Philosoph. Soc., III. 464, 1830.—Medical and Physical Researches, p. 229, fig. 1, 1835.

Astacus Blandingii, Milne Edwards, Histoire Naturelle des Crustacés, II. 332, 1837. (After Harlan.)

Astacus Blandingii, De Kay, Zoölogy of New York, Part VI. Crustacea, p. 23, 1844. (After Harlan.)

Astacus (*Cambarus*) *Blandingii*, Ericuson, Arch. f. Naturgesch., Jahrg. XII., I. 98, 1846. (After Harlan.)

? *Astacus Blandingii*, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 400, 1855.

Cambarus Blandingii, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III., 43, Pl. I. figs. 63, 64, Pl. III. fig. 140, 1870.

Cambarus acutus, var. B, Hagen, *op. cit.*, p. 36, Pl. III. fig. 144, 1870.

Cambarus acutus, Abbott? Amer. Naturalist, VII. 80, 1873. (Habits.)

Cambarus acutus (in part), Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 637, 1874. (After Hagen and Abbott. No description.)

Cambarus Blandingii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 135, 1884.

Known Localities.†—New York. New Jersey: Essex Co.; Delaware River and tributaries, near Trenton. Maryland: Baltimore Co. (Coll. P. R. Uhler);

* In some specimens of *C. fallax* the hinder section of the carapace is a little less than one half the distance from the cervical groove to the tip of the rostrum. *C. maniculatus* (Le C.) is omitted from the above table, as I have seen no specimens answering to the description of Le Conte.

† Localities for which no authority is given in parentheses are represented in the collection of the Museum of Comparative Zoology.

Caroline Co. (Coll. P. R. Uhler); Dorchester Co. (Coll. P. R. Uhler); St. Mary's Co. (Coll. P. R. Uhler); Somerset Co.; Wicomico Co. (Coll. P. R. Uhler); Worcester Co. Virginia: James River (Coll. Acad. Nat. Sci. Phila.); Lunenburg (Coll. L. A. Lee). North Carolina: Tarboro (Coll. U. S. Nat. Mus.); tributaries of Neuse River, Goldsboro (P. R. Uhler); Kinston; Beaufort; Salmon Creek (Coll. U. S. Nat. Mus.); Wilmington (Coll. U. S. Nat. Mus.). South Carolina: Camden (Coll. Acad. Nat. Sci. Phila.); Saluda River (Coll. Butler Univ.); Columbia. Georgia: Richmond Co.

Var. acuta.

Cambarus acutus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 91, 1852.
Cambarus acutissimus, Girard, *loc. cit.*, 1852.
Cambarus acutus, Hagen, Ill Cat. Mus. Comp. Zoöl., No. III., 35, Pl. I. figs. 1–5, Pl. II. figs. 106, 108, 110–114, 116, 118, 120–124, 126, 127, Pl. III. fig. 143, 1870.
Cambarus acutus, var. A, Hagen, *op. cit.*, p. 36, Pl. II. figs. 107, 109, 115, 117, 119, 125, 1870.
Cambarus acutus (in part), Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 637, 1874. (After Hagen. No description.)
Cambarus acutus, Forbes, Bull. Ill. Mus. Nat. Hist., No. I., 3, 18, 1876.
Cambarus acutus, Bundy, Trans. Wis. Acad. Sci., V. 180, 1882. — Geol. Wis., Surv. 1873–79, I. 402, 1883. (No description.)
Cambarus Blandingii, var. *acuta*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 136, 1884.

Known Localities. — Louisiana: New Orleans; Amite City, Tangipahoa River (Coll. U. S. Nat. Mus.); Tickfaw (Coll. U. S. Nat. Mus.). Mississippi: near Vicksburg; Kemper Co., tributary of Tombigbee River (Coll. Acad. Nat. Sci. Phila.). Alabama: Mobile; Blount Spring, Blount Co. (Coll. U. S. Nat. Mus.); Cullman, Cullman Co. (Coll. U. S. Nat. Mus.); Decatur, Morgan Co. (Coll. U. S. Nat. Mus.); Bridgeport, Jackson Co., in pond formed by overflow of Tennessee River. South Carolina: Beaufort (Coll. Acad. Nat. Sci. Phila.); Charleston. Tennessee: Memphis (Coll. O. P. Hay). Missouri: St. Louis. Illinois: Athens, Menard Co. (Coll. Peabody Acad. Sci.); Decatur, Macon Co.; Pekin, Tazewell Co. (S. A. Forbes); Normal, McLean Co. (Peabody Acad. Sci.); Oquawka, Henderson Co. (Coll. O. P. Hay); Peoria, Peoria Co.; Lawn Ridge,* Marshall Co.; Evanston, Cook Co. Indiana: Wheatland, Knox Co. Iowa: West Liberty; Dubuque (Peabody Acad. Sci.). Wisconsin: Racine (W. F. Bundy); Sauk City (W. F. Bundy).

Harlan's type is still preserved in the collection of the Academy of Natural Sciences of Philadelphia, and has been well described by Hagen. It came

* The localities "Basson Ridge" and "Basson Pudge," given by Hagen (pp. 37, 39, 97, 102), are false readings of the MS. label "Lawn Ridge."

from Camden, a town near the Wateree River, Kershaw Co., S. C. Compared with Girard's *C. acutus*, from farther south, the rostrum is longer, with longer acumen; carapace smoother, although granulated on the branchial regions; lateral thoracic spine prominent; antennal scale longer and much narrower; hand longer, more cylindrical, the squamous tubercles not tending to form a definite line of teeth on the inner margin, as in *C. acutus*. Harlan says, "All the crawfish which I have seen from the Southern States (and I have received specimens from New Orleans and South Carolina) are of the same species with that now described."* It is probable that he included in this species not only *C. acutus*, but also other allied species, as *C. troglodytes*, &c.

Among specimens collected for the U. S. National Museum by Col. M. M. McDonald in the neighborhood of Columbia, S. C., (a city thirty-two miles southwest of Camden, in the same river basin,) are several which nearly resemble Harlan's type. They are younger, and the males are all of the second form, with small chelæ. The antennal scale is somewhat broader than in Harlan's specimen. Lateral thoracic spine well developed. The largest male is $3\frac{1}{4}$ inches in length, chelipeds $2\frac{3}{8}$ inches.

In the collection of Butler University, Irvington, Ind., there is a first form male of the same species from the Saluda River, S. C., collected by Prof. D. S. Jordan. The Saluda River unites with the Broad River at Columbia to form the Congaree. The chelipeds have been lost. The antennal scale is somewhat broader than in Harlan's type, but in other respects, including the form of the anterior abdominal appendages, it agrees with it. Length, 3 inches.

In specimens from the low country of North Carolina, Maryland, and New Jersey, the rostrum narrows nearer the base, and the hand is closely set with ciliate squamous tubercles. In some individuals from North Carolina the cardiac region of the carapace is shorter in proportion to the anterior portion than in the ordinary form (less than one half the distance from tip of rostrum to the cervical groove).

Cambarus acutus of Girard, from the South and West, is a larger form, with quite a differently shaped hand and rostrum and a shorter abdomen; but after a careful study of a very large number of specimens from the Atlantic and Gulf States and the Mississippi Valley, I am inclined to consider them forms or varieties of one species. The male sexual appendages

* Trans. Amer. Philosoph. Soc., III. 465.

are the same in all essential regards, and specimens intermediate in the form of the hands, rostrum, and antennal scale are frequently met with.

Two dry male specimens in the Museum of the Academy of Natural Sciences of Philadelphia, from Kemper Co., Miss., labelled "*C. acutissimus*?" are probably types of the species described under that name by Girard. They appear to be young specimens of *C. acutus*.

The specimens of *C. Blandingii*, var. *acuta*, received from the Western States differ somewhat from those of the Southern States, as pointed out by Hagen on page 36 of the Monograph of the North American Astacidæ. They form a sub-variety designated by the letter A.

Dr. Hagen considers Le Conte's *A. Blandingii* to be his *C. Lecontei*. No type of Le Conte's species is known, but the description and habitat (middle regions of Georgia and Carolina) fit *Blandingii* better than *Lecontei*.

Gibbes and Girard seem to have confounded this species with *C. troglodytes*. There is a specimen of *C. troglodytes* in the Museum of Comparative Zoölogy, sent by Gibbes with the label "*Astacus Blandingi* Harl.," and the localities given by him,* viz. "the low country of South Carolina," and by Girard, viz. "Summerville, S. C.," refer to *C. troglodytes*.

From Montgomery, Ala., comes a form which agrees with *C. Blandingii* in all respects except the male sexual appendages, which approach those of *C. Lecontei* in the curvature of the two anterior apical teeth. The posterior apical tooth is straight, as in *C. Blandingii*. In many of the larger specimens there are three spines on each side of the telson. This may perhaps prove to be a distinct species.

Two female specimens in the Museum of Comparative Zoölogy, from Dallas, Texas, agree well with *C. Blandingii*, but it is difficult to determine them positively in the absence of male specimens. They were collected by J. Boll, and are labelled "Burrowing Crabs."

In specimens of var. *acuta*, subvar. A, from the West, that have not lain long in alcohol, the rostrum is red (in some specimens only a pair of red blotches at the base), and there appears a good deal of red color on the dorsal side of the abdominal segments and the basal segment of the telson and swimmerets. Living specimens of *C. Blandingii* collected by me near Trenton, N. J., are of a dull greenish brown, whitish beneath and on the lower part of the carapace, with a dark-greenish longitudinal stripe on each

* On the Carcinological Collections of the Cabinets of Natural History in the United States. Proc. Amer. Assoc. Adv. Sci., pp. 167–201, 1850.

branchial region, half-way between the areola and the lower border, and a whitish longitudinal band on each side of the abdominal somites, these bands not reaching to the hind border of the somites. The tubercles of the chelæ are black, and there are dark spots on the margin of the rostrum.

Dr. Abbott* states that in Trenton, N. J., this species frequents "running streams which have masses of vegetation growing in them, the animal in question resting upon the plants, usually near the surface of the water. We have found since our collecting excursions, on carefully approaching clear running streams, such as just mentioned, that this crawfish is to be seen resting on the plants, always with the head directed above stream. If disturbed, they would dart backwards down to the roots, apparently, of the plant upon which they were sitting. After a lapse of about ten minutes, they would return to their former resting-place, creeping up the plant down which they had so suddenly darted tail foremost."

Mr. P. R. Uhler, in his studies on the distribution of the crayfishes of Maryland, finds that this species belongs to the lowlands at the mouth of sluggish rivers, or near the ocean in muddy and grassy ditches and drains, and even in salt water, in company with *C. Uhleri*. In his collection are specimens from near Ocean City, Worcester Co., Md., found in a ditch in holes six to nine inches deep. At Goldsborough, N. C., the same gentleman found it abundant in drains and branches running through cotton fields, tributaries of the Neuse River.

C. Blandingii, var. *acuta*, attains a very large size. The largest I have seen, a male of the first form, is $5\frac{1}{8}$ in. in length. The cheliped is $6\frac{7}{8}$ in., the chela $3\frac{7}{8}$ in. This specimen is in the Museum of Comparative Zoölogy.

2. Cambarus fallax.

Plate II. fig. 4.

Cambarus fallax, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 45, Pl. I. figs. 103–105, 1870.
Cambarus fallax, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 136, 1884.

Known Localities. — Florida: St. John's River at Jacksonville, Orange Bluff, Hawkinsville, Horse Landing, Blue Spring (Coll. Peabody Acad. Sci.), and Lake Jessup (Coll. U. S. Nat. Mus.); Magnolia (Coll. Boston Soc. Nat. Hist.); Indian River (Coll. U. S. Nat. Mus., Yale Coll.); Titusville, Brevard Co. (Coll. U. S. Nat. Mus.).

* Amer. Naturalist, VII. 80.

The four type specimens, collected by Dr. H. Bryant, are 1 ♂ form I., 2 ♂ form II., 1 ♀. The measurements given by Hagen are those of the largest specimen, ♂ form II. This is the largest specimen I have seen. *C. fallax* is very near *C. Blandingii*, which it seems to replace in the State of Florida. It is easily distinguished from the latter species by the male appendages, which are curved backwards at the end, and armed with only minute teeth at the tip. The distal margin of the proximal segment of the telson is armed on each side with three or four spines. In a few specimens from Hawkinsville, St. John's River, Fla., the acumen of the rostrum is lengthened, the lateral spines of the rostrum are stronger, and the portion of the carapace behind the cervical suture is shortened. The specimens thus approach *C. Lecontei*. The shortening of the posterior part of the carapace is not so great as in *C. Lecontei*, the areola is narrower, and the male appendages do not differ from those of the typical *C. fallax*. In the ordinary form of *C. fallax* the distance from the tip of the rostrum to the cervical groove is twice the distance from the cervical groove to the hind border of the carapace. In the abnormal specimens just noticed the anterior distance is two and one third times that of the posterior; in *C. Lecontei* it is two and one half times. In many specimens, contrary to Hagen's description, the antennæ are much longer than the body, and in well-developed males of the first form the chelæ are inflated and cylindrical. Specimens of this species, now in the Museum of the Peabody Academy of Science, Salem, were collected by C. J. Maynard, in Blue Spring, St. John's River, a mineral spring impregnated with sulphur and magnesia, — temperature 70° Fahr. They were clinging to the under side of leaves.

3. Cambarus Hayi.

Plate I. fig. 4, Plate VII. figs. 3, 3′, 3a, 3a′.

Cambarus Hayi, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 108, 1884.

Male, form I. Rostrum broad, triangular, excavated, sparsely pubescent above; acumen short, lateral spines moderate. Carapace punctate above, granulated on the sides, the granules ciliate. Lateral spines slightly developed in fully-grown individuals, more prominent in the young. Areola narrow. Abdomen broad, shorter than the cephalo-thorax. Pleural angles rounded. Proximal segment of telson with two spines on each side of the distal border. Hind margin of telson slightly concave. Anterior process

of epistoma broadly triangular. Antennæ shorter than the body. Antennal scale a little shorter than the peduncle, equal to the rostrum, broad, broadest at the middle. Chelipeds slender, chela long, inner and outer margins parallel, squamoso-tuberculate, tubercles ciliate, those along the inner margin of the hand blunt spiniform. Fingers longer than the hand. Opposed margins of fingers ciliate, with one or two small spinous teeth. Carpus long triangular, smooth without, tuberculate and spinous within. Meros with scattered impressed dots without, tuberculate on the upper margin; one or two spines at the anterior end of upper margin, two rows of spines beneath. Third and fourth pairs of legs hooked on third segment. Anterior abdominal legs of moderate length, deeply excavated on the outer side near the tip; a beard-like tuft of cilia from the protuberance behind the excavation; the tip bears three flattened horny teeth; inner part ciliate, with a long spine directed outwards and forwards.

The second form of the male has shorter chelipeds, smaller hooks on the second and third pairs of legs, the terminal teeth of the first pair of abdominal legs smaller and not corneous.

In the female the chelipeds are short, the chelæ broad. Sternum bituberculate between the fourth pair of legs. Annulus ventralis umbilicoid, with a tubercle in the median depression.

Length, 100 mm. Rostrum, 15 mm.; acumen, 3 mm. Length of carapace, 51 mm. From cervical groove to posterior margin of carapace, 18.5 mm. Abdomen, 50 mm. Width of areola, 1.5 mm. Chelipeds, 92 mm. Chela, 43 mm.

Known Localities. — Mississippi: Macon, Artesia.

Closely related to *Cambarus Blandingii*, but easily distinguished by the first pair of abdominal legs of the male, which are characteristic even in very small specimens. Over a dozen specimens of this species (including males of the first form, males of the second form with first pair of abdominal appendages articulated near the base, and unarticulated, and females) were collected by Prof. O. P. Hay in Eastern Mississippi. One lot has a particular locality specified, — Macon. Macon is situated on the Noxubee, an affluent of the Tombigbee River. Another lot was collected at Artesia, a town about twenty miles north of Macon.

4. Cambarus Clarkii.

Cambarus Clarkii, Girard, Proc. Acad. Nat. Sci. Philad., VI. 91, 1852.
Cambarus Clarkii, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 39, Pl. I. figs. 7–10, 99, 100, Pl. II. figs. 133, 134, Pl. III. fig. 142, Pl. IV. (this figure is copied on a reduced scale in Huxley's "Crayfish," p. 248, 1880), 1870.
Cambarus Clarkii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 136, 1884.

Known Localities. — Texas: between San Antonio and El Paso del Norte (Girard); San Antonio; Clear Creek, Waller Co. (Coll. U. S. Nat. Mus.). Louisiana: New Orleans; Tangipahoa River (Coll. U. S. Nat. Mus.). Mississippi: Ocean Springs, Jackson Co. (Coll. U. S. Nat. Mus.). Alabama: Mobile. Florida: Pensacola (Coll. U. S. Nat. Mus.); three miles below Horse Landing, St. John's River. Ohio: Olmsted [?].

Girard's specimens were collected between San Antonio, Texas, and El Paso del Norte, by John H. Clark, of the U. S. Mexican Boundary Commission. The original description of the species is hardly sufficient for determination, but fortunately Dr. Hagen was able to identify the species by an examination of Girard's types, which were probably lost in the great fire at Chicago, whither they were sent to Dr. Stimpson. A full description of *C. Clarkii* is given on page 39 of Hagen's Monograph.

In specimens collected by Edward Palmer at San Antonio, Texas, the carapace is smoother than in the form commonly received from New Orleans and Mobile, with more prominent lateral and postorbital spines. The rostrum tapers much less than in the form from farther east, the sides being more nearly parallel. The areola, moreover, is not entirely obliterated in the middle, but forms a linear area about as wide as in *C. troglodytes*. The male sexual appendages do not differ from those of the Louisiana specimens. This is probably the form described by Girard.

In this connection it is interesting to note that in young individuals of this species eight millimeters long, taken from beneath the abdomen of a female from New Orleans, the areola is proportionally even wider than in the San Antonio specimens.

In a male, form II., 60 mm. long, collected by J. A. Allen in St. John's River, Fla., the areola is like that described in the San Antonio specimens, and the distal margin of the proximal segment of the telson is armed with three or four spines on each side. The carapace is smooth.

A female specimen, 92 mm. long, in the Academy of Natural Sciences of Philadelphia (No. 654), from the Smithsonian Institution, without locality,

differs in some respects from any other seen by me. The granules of the carapace are larger, the gastric area more heavily punctate, the rostrum is longer (14 mm., the whole carapace being 48 mm., while in New Orleans specimens the rostrum is only one fourth the length of the carapace), with longer acumen and lateral spines, and narrower at the base, than in New Orleans specimens, with less converging sides; the arm is more conspicuously tuberculated along its upper edge. The lateral thoracic spines are prominent, as in the San Antonio form. The areola is obliterated in the middle, as in specimens from Louisiana and Alabama.

A dry cephalothorax of a female in the Museum of Comparative Zoölogy (No. 3337), referred to *C. troglodytes* by Hagen (pp. 42, 43), seems to belong to *C. Clarkii*. As dry specimens are easily transposed, and this is the only specimen recorded from the North, I believe the locality to be erroneous.

C. Clarkii is the species commonly on sale in the New Orleans market.

5. Cambarus troglodytes.

Astacus troglodytes, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 400, 1855.
Astacus fossarum, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 401, 1855.
Cambarus troglodytes, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 41, Pl. I. figs. 11–14, Pl. II. fig. 141, 1870.
Cambarus troglodytes, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. pp. 4, 18, 1876. (After Hagen.)
Cambarus troglodytes, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 136, 1884.

Known Localities. — Lower Georgia; Richmond Co., Ga. South Carolina: Charleston; Oakley (Coll. U. S. Nat. Mus.); Columbia (Coll. U. S. Nat. Mus.). Illinois: Lawn Ridge, Marshall Co. [?].

This species resembles *C. Clarkii* very closely, but is readily distinguished by the first pair of abdominal legs of the male, and by the rostrum, which is nearly plane above, with very slight marginal teeth (often obsolete), and shorter acumen. The areola is very narrow, but not obliterated, in the middle.

Two of Le Conte's types (both males, form I.) are extant, one in the Museum of Comparative Zoölogy, and one in the Academy of Natural Sciences of Philadelphia. In each of these museums there is also a small female type of *C. fossarum* of Le Conte, which does not differ essentially from *C. troglodytes* of the same author. It is difficult to see why Le Conte separated the two, unless on the ground of a difference in color during life.

Both Girard and Gibbes (Proc. Amer. Assoc. Adv. Sci., 3d Meeting) appear to have confounded this species with *C. Blandingii* Harlan. A female *C. troglodytes* in the Museum of Comparative Zoölogy, from South Carolina, is labelled "*Astacus Blandingi* Harl." by Professor Gibbes. The localities for *C. Blandingii* (Summerville, S. C., and low country of South Carolina) given by these authors undoubtedly appertain to *C. troglodytes*.

Slight differences between specimens from Georgia and Charleston, S. C., are pointed out by Hagen (pp. 42, 43). In one of the Georgia specimens the telson is quadrispinose. In specimens from near Columbia, S. C., the basal segment of the telson is bispinose on each side.

The rostrum is sometimes slightly carinated near the tip.

I doubt the accuracy of the locality label of the specimen of this species in the Museum of Comparative Zoölogy numbered 197. It was taken from a jar containing *C. Diogenes* from Lawn Ridge, Ill. No other specimens have been reported from the West.

The specimen in the Museum of Comparative Zoölogy (No. 3337) labelled Rocky River, Olmsted, Ohio, determined as *C. troglodytes* by Hagen (p. 43), seems to be *C. Clarkii* (see p. 27).

According to colored drawings of this species made from living specimens by J. Burkhardt at Charleston, in 1853, the body is brownish red, the tubercles on the chelæ bright red, legs red below.

Dr. Le Conte states that in Lower Georgia this species is found in the rice-fields, where it makes holes four inches deep, and in ditches (*A. fossarum*).

Specimens from Richmond Co., neighborhood of Augusta, Ga., received recently from Col. Charles C. Jones, Jr. (Cat. No. 3550), are noteworthy in that the male appendages, especially of the second form, approach closely in their form those of *C. Clarkii*. In the shape of the rostrum and other respects these specimens agree with *C. troglodytes*. The telson is trispinose on each side. In the light of these specimens, I am inclined to suspect that further explorations will break down the specific distinctions between *C. troglodytes* and *C. Clarkii*. But my material does not represent a wide enough geographical range to warrant a definite opinion.

6. Cambarus maniculatus.

Astacus maniculatus, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 401, 1855.
Cambarus maniculatus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 52, 1870. (After Le Conte.)
Cambarus maniculatus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 137, 1884. (After Le Conte. No description.)

This species is known only from the description of Le Conte, which is quoted in full on page 52 of Hagen's Monograph. The description was perhaps drawn up from an immature specimen of *C. troglodytes*. The number of hooked thoracic legs in the male is not specified in Le Conte's description, but the species is probably one of the *C. Blandingii* group, since it is placed among the species of that group in Le Conte's list.

7. Cambarus Lecontei.

Plate II. fig. 2.

Cambarus Lecontei, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 47, Pl. I. figs. 15–18, Pl. III. fig. 145, 1870.
Cambarus Lecontei, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 137, 1884.

Known Localities. — Alabama: Mobile. Georgia: Athens.

Resembles *C. Blandingii* and *C. fallax*, but is easily distinguished from these by the shortness of the portion of the carapace behind the cervical groove, the greater length of the acumen of the rostrum, antennal scale, and chelæ, and the shape of the male sexual appendages. The areola is somewhat wider. The rostrum is deeply excavated above, the sides converging but slightly up to the lateral teeth, which are separated by more than one half of the width of the base of the rostrum. The proximal segment of the telson is armed on each side of its distal margin with three or four teeth.

The proportions may be seen from the following measurements of a male, form I.: Length of body, 86 mm.; of carapace, 43 mm.; of abdomen, 48 mm. From tip of rostrum to cervical groove, 31 mm.; from cervical groove to posterior border of carapace, 12 mm. Length of rostrum, 14 mm.; of acumen, 5 mm. Breadth of rostrum at base, 7 mm.; at lateral spines, 4 mm. Breadth of areola, $2\frac{1}{3}$ mm. Length of chela, 40 mm.; breadth, 8 mm.

Smaller specimens are more characteristic on account of a greater proportional breadth of the areola and shortness of posterior portion of the carapace. In a male, form II., 65 mm. in length, the length of the carapace from the tip of rostrum to cervical groove is 24 mm.; from cervical groove to posterior border of carapace, 8.5 mm. Breadth of areola, 2 mm.

The types of *C. Lecontei* came from Mobile, Ala. The specimens from other localities assigned to this species by Hagen, on page 48 of his Monograph, certainly do not belong here. The specimens from Beaufort, N. C., and Root Pond, Miss., are *C. Blandingii*. The female from Milledgeville, Ga. (No. 246) ill agrees with the types, on account of the shortness of the acumen of the rostrum (the rostrum being like that of *C. Blandingii*), the short and broad antennal scales, breadth of the hand, etc. Of the three young specimens, one is *C. spiculifer*, the others are too small to be determined with any certainty. The three specimens from Pensacola, Fla. (No. 249) are young (one female, two males), and resemble *C. Lecontei* only in the shortness of the posterior portion of the carapace and the width of the areola; in other respects, they are like the smooth form of *C. Blandingii*, var. *acuta*. There is no lateral spine on the carapace, and the telson is bispinose.

Besides the Mobile types, I have found but one other specimen of this species in the Museum, a young female in a jar with *C. spiculifer* (Cat. No. 172), from Athens, Ga.

8. Cambarus angustatus.

Astacus angustatus, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 401, 1855.
Cambarus angustatus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 50, Pl. I. figs. 65–67, Pl. III. fig. 146, 1870.
Cambarus angustatus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 137, 1884.

Locality. — Lower Georgia.

This species is known only through a dry type specimen in the Museum of the Academy of Natural Sciences of Philadelphia. Le Conte's description of the species is as follows: —

"*A. angustatus.* — Rostrum concavum, valde acuminatum, utrinque versus apicem fortiter et acute unidenticulatum. Lamina antennalis pedunculum antennalem æquans. Cephalothorax punctatus, parcius ad latera, adeo ut vix paucis punctis notatur, linea ordinaria apice spina armata. Thorax totus punctatus, parcius ad latera, tuberculis vel granulis nullis. Areola suturalis lata. Dorsum sicut in prioribus [i. e. glabrum seriebus parvis punctorum transversalium]. Chela parva, angusta, subcylindrica, punctata, sine tuberculis aut granulis, excepto margine interiore qui paucis denticulus inconspicuis instructus est, digiti recti punctati carinati. Carpus glaber, punctis tribus vel quatuor. Brachium glabrum, spinulis paucis latere superiore: inferiore seriebus duabus spinarum, quarum duæ anteriores majores et longiores. Caudæ lamella intermedia utrinque trispinosa.

"Long. 1.95. Cephalothorax .6. Thorax .25. Abdomen .8. Cauda .3. Antenna .9. Chela .6, latitud. .2, forceps .3.

"Habitat in Georgia inferiore, in aquæ puræ rivulos qui inter colliculos arenosos (*sand-hills*) currunt."

The Philadelphia type agrees well with Le Conte's description. The chela, however, under close inspection, is seen to be covered with obsolescent, ciliate, squamous tubercles, and the areola is moderate rather than wide. The fingers are ciliated along their inner margins. There is a single lateral spine on each side of the thorax, three spines on the right side of the telson, four on the left side. Carpus with two prominent spines on the inside, and one below, near the exterior articulation of the hand. The sides of the rostrum converge but little from the base to the lateral spines. The acumen is long. The sexual appendages are figured by Hagen. The measurements of this specimen (a male, form I.) are these : —

Length, 47 mm. Carapax, 22 mm. Abdomen, 25 mm. From tip of rostrum to cervical groove, 16 mm. From cervical groove to posterior border of carapace, 6 mm. Length of rostrum, 8 mm. ; acumen, 3 mm. Width of rostrum at base, 3 mm.; between lateral spines, 2 mm. Width of areola, 1.5 mm. Length of chela, 15 mm. ; breadth of do., 4 mm.

It resembles *C. Leeontei* in general appearance, the shape of hand, and number of lateral thoracic and telson spines. The first pair of abdominal legs are different, resembling those of *C. spiculifer*, but different from either. The sides of the rostrum are more nearly parallel than in *C. Leeontei*, in this respect resembling *C. versutus*. It seems to be a very much smaller species than its near allies.

9. Cambarus pubescens.

Plate I. fig. 3, Plate VIII. figs. 1 a, 1 a.

Cambarus pubescens, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 109, 1884.

Male, form II. — Rostrum long, triangular, sides subparallel at the base, then converging towards the lateral spines, which are evident; slightly depressed above at the base, subplane, with raised margins; ciliated, especially on the acumen; acumen long, pointed. Post-orbital ridges with anterior spines. Carapace cylindrical, fore border angulated behind the antennæ, punctate above, slightly granulated on the sides, with one lateral spine on each side. Cervical groove ciliated. Cardiac region short (much less than

one third as long as the anterior part of the carapace). Areola broad. Sternum covered with a dense growth of coarse setæ. Abdomen longer than the cephalothorax. Proximal segment of telson armed on each side with four spines. Anterior process of epistoma broad triangular with ciliated margin. Basal segment of antennule with a sharp spine below, near the inner margin of the middle of its length. Antennæ shorter than the body. Second and third segments with acute external spine; scale a little longer than peduncle of antennæ and rostrum, moderately broad, broadest below the middle. Third maxillipeds hairy within and below. Chela moderately broad, covered with inconspicuous ciliate squamous tubercles, internal margin nearly straight. Fingers as long as the hand, densely ciliated. Carpus tuberculate, a prominent spine within, and one near each point of articulation with the chela. Meros smooth outside and inside, tuberculate and spinous above, biserially spinous and ciliate beneath. Third and fourth pairs of legs toothed on the third segment. Fifth pair of legs with a hook on the basal segment. Anterior abdominal appendages of moderate length, articulated at the base, internal part with an articulated spine obliquely placed, external part terminating in a rounded head with two short, blunt teeth.

Female. — Differs from the male in its shorter and smaller claws. The sternum is densely ciliated, as in the male. The annulus ventralis conical with sigmoid longitudinal fissure; movable.

Length, 54 mm. Carapace, 26 mm. Abdomen, 29 mm. Distance from tip of rostrum to cervical groove, 19 mm.; from cervical groove to posterior border of carapace, 7 mm. Width of areola, 3 mm. Length of chela, 15.5 mm.; breadth, 4 mm. (In the female, which is 59 mm. long, the chela is 12 mm. long by 4 mm. wide.)

Two specimens, one male of the second form and one female, in the U. S. National Museum (No. 3181), collected by A. Graves in McBean Creek, a tributary of the Savannah River a little south of Augusta, Georgia, are the types of this species. There are two young female specimens from the same region, Richmond Co., in the Museum of Comparative Zoölogy.

Differs from *C. Lecontei* and *C. angustatus* by its broader areola, subplane rostrum, and the pubescence of rostrum and cervical groove. The male appendages also differ, as shown in the description and figures.

10. Cambarus spiculifer.

Plate II. fig. 5.

Astaeus spiculifer, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 401, 1855.
Cambarus spiculifer, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 48, Pl. I. figs. 59–62, Pl. III. fig. 147, 1870.
Cambarus spiculifer, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 138, 1884.

Known Localities.—Upper Georgia: Oconee River at Athens and Milledgeville; Ocmulgee River in the neighborhood of Atlanta (Coll. Butler Univ., from D. S. Jordan); Chattahoochee River at Roswell, Cobb Co., and near Gainesville; Etowah River (Coll. Butler Univ., from D. S. Jordan).

There is a male type, form I., in the Museum of Comparative Zoölogy, and one in the Academy of Natural Sciences of Philadelphia.

In none of the specimens seen by me are there three spines on each side of the basal segment of the telson, as is said by Hagen to be sometimes the case (p. 49), nor have I seen an individual with but one lateral thoracic spine (Hagen, p. 50). I think these statements are based upon erroneous determinations, for in the jarful of specimens from Athens, Ga., labelled *Cambarus spiculifer* by Hagen, I find the young of *C. Lecontei*, which has a trispinous telson and one lateral thoracic spine.

Measurements of a male, form II.—Length, 71.5 mm. Carapace, 34.5 mm. Abdomen, 37.5 mm. From tip of rostrum to cervical groove, 25.5 mm.; from cervical groove to posterior margin of carapace, 9 mm. Length of rostrum, 11.25 mm.; breadth of rostrum at base, 5.5 mm.; between lateral spines, 2.75 mm. Length of chela, 29 mm.; breadth of do., 11 mm. Width of areola, 3.5 mm. The largest specimen seen by me is 97 mm. long, male form II.

Cambarus spiculifer has been found as yet only in Upper Georgia, in the Altamaha and Chattahoochee River basins.

C. Lecontei, *C. angustatus*, *C. pubescens*, *C. spiculifer*, and *C. versutus* are distinguished from the other species of Group I. by the shortness of the cardiac region of the carapace. *C. Lecontei*, *C. angustatus*, and *C. pubescens* have one lateral thoracic spine on each side; *C. spiculifer* and *C. versutus* have two. *C. Lecontei* and *C. angustatus* have subcylindrical hands, areola of moderate width, rostrum smooth and hollowed out above; *C. pubescens* has broader hands and areola, rostrum pubescent and subplane above. In *C. angustatus* the sides of the rostrum are subparallel; in *C. Lecontei* the rostrum is more tapering. In both *C. spiculifer* and *C. versutus* the areola is

wide and the hands broad; *C. versutus* has the hand covered with small, close-set, squamous tubercles, the sides of the rostrum are subparallel, and the telson commonly tri- or quadrispinose on each side; in *C. spiculifer* the hands bear large tubercles much less closely set than in *C. versutus*, the rostrum tapers more between the base and the lateral spines, and the telson is bispinose on each side. Each of these five species has characteristic male appendages, figured by Hagen and on Plate VIII. of this Revision.

11. Cambarus versutus.

Cambarus versutus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 51, Pl. I. figs. 55–58, Pl. III. fig. 150, 1870.

Cambarus versutus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 138, 1884.

Known Localities. — Alabama: neighborhood of Mobile. Florida: Cape Barrancas [Pensacola Bay ?].

Cambarus versutus resembles *C. spiculifer* in the shortness of the carapace behind the cervical groove, the wide areola, and the two spines on each side of the carapace. In addition to the difference in the male appendages (see Hagen's figures), the chelæ are covered with small, closely-set squamous tubercles, while in *C. spiculifer* the chelæ have fewer and larger tubercles. In *C. versutus* the hand is sulcated below, along the inner border, and the areola is a little wider. The telson is tri- or quadrispinose in *C. versutus*, bispinose in *C. spiculifer*. The sides of the rostrum converge less between the base and the lateral spines in *C. versutus*.

Measurements of a male, form I. — Length, 73.5 mm. Carapace, 35 mm. Abdomen, 38.5 mm. From tip of rostrum to cervical groove, 26 mm.; from cervical groove to posterior border of carapace, 8.5 mm. Length of rostrum, 12 mm.; acumen, 5 mm. Breadth of rostrum at base, 5.5 mm.; between lateral spines, 4 mm. Length of chelæ, 33 mm.; breadth of do., 11 mm. Width of areola, 4 mm.

Three small dry specimens, two males and one female, from Cape Barrancas, Fla., differ from the Alabama specimens in that the rostrum tapers a little more and is lightly carinated above in the middle third of the median line. Although none of the specimens are over 40 mm. in length, the males are of the first form, with well-developed hooks on the third and fourth pairs of legs. The male appendages agree with those of *C. versutus*. The telson is tri- or quadrispinose, and the hand is sulcated below, along the inner margin, as in *C. versutus*.

12. Cambarus Alleni.

Plate I. fig. 1, Plate VIII. figs. 2, 2.

Cambarus Alleni, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 110, 1884.

Male, form I. — Rostrum broad, triangular, somewhat deflexed, smooth, excavated above, margins raised into sharp crests and gradually converging to near the tip, where they suddenly come together to form the short, sharp acumen; no lateral spines. Post-orbital ridges without spines. Carapace cylindrical, somewhat compressed laterally, fore border angulated behind the antennæ, punctate above, granulated on the sides. Cervical groove deeply sulcated, without lateral spines. Cardiac region more than one third as long as the distance from the tip of rostrum to hind border of carapace. Areola narrow. Abdomen broad, longer than cephalothorax. Angles of pleura rounded. Three or four spines on each side of posterior border of basal segment of the telson. Terminal segment of telson shorter than basal part, one third broader than long, hind margin concave. Anterior process of epistoma subquadrangular. Basal segment of antennules with a sharp spine below, near the inner margin, half-way towards the end of the segment. Antennæ shorter than the body, second and third segments with an external sharp tooth. Antennal scale equal to peduncle, slightly surpassing the rostrum, broad, broadest at the middle, rounded at apex, terminating in a short spine, external margin inflated. Third maxillipeds hairy within and below. Chelipeds slender, chela long, subcylindrical, squamoso-tuberculate, tubercles ciliate anteriorly, internal border straight, serrate. Fingers as long as the hand, with alternate longitudinal ribs and lines of ciliate impressed dots. Opposed margins of fingers straight, unidentate. Carpus squamoso-tuberculate within, obsoletely so without, with one prominent spine on inner border. Meros punctate outside, ciliato-tuberculate within and on upper margin, which has two ante-apical spines obliquely placed; two rows of spines beneath. Third and fourth pairs of legs hooked on third segments, hooks of fourth pair bituberculate. Fifth pair of legs with a flattened laminate tubercle on basal joint. Anterior abdominal appendages of moderate length, bifid at apex, outer part forming a broad flattened plate whose anterior margin is furnished with hairs and one strong seta, the posterior margin of the plate produced anteriorly into a blunt tooth-like process. Inner part bearded within, and produced into a long erect spine, which much exceeds in length the outer part of the appendage.

Length, 62 mm. Rostrum, 6 mm. Carapace, 30 mm. From tip of rostrum to cervical groove, 19.5 mm.; from cervical groove to posterior border of carapace, 10.5 mm. Abdomen, 32 mm. Width of areola, 7 mm. Antennæ, 47 mm. Chelipeds, 49 mm. Chela, 23 mm. Width of chela, 6 mm.

St. John's River, Hawkinsville, Orange Co., Fla.: J. A. Allen.

A well-marked species with toothless excavated rostrum (younger specimens probably have marginal rostral teeth), narrow areola, long, subcylindrical chelipeds covered with ciliated squamous tubercles. The first abdominal legs are not jointed, the hooks on the third and fourth pairs of thoracic legs are large and well finished, so that I consider the single specimen examined to be the first form.

In the collection of the Academy of Natural Sciences of Philadelphia is a specimen from Hernando Co., Fla., Jos. W. Wilcox, which is probably the second form of the male of this species. The sexual appendages are not articulated at the base. The hooks on the third and fourth pairs of legs are small, tooth-like processes merely. Besides the differences in these hooks and in the sexual appendages, the following may be pointed out: the rostrum has small lateral teeth near the tip, the post-orbital ridges have a sharp spine at their anterior end, the basal segment of the fifth pair of legs is armed with a sharp hooked tooth in place of a flattened tubercle, and the hind segment of the telson is longer in proportion to its width.

13. Cambarus penicillatus.

Astacus penicillatus, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 401, 1855.
Cambarus penicillatus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 53, Pl. I. figs. 93, 94, [95, 96 ?], Pl. III. fig. 149, 1870.
Cambarus penicillatus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 138, 1884.

Known Localities. — Georgia. Eastern Mississippi [?]. Charleston, S. C. [?].

None of Le Conte's types of this species are known. Of the specimens in the Museum of Comparative Zoölogy referred to this species by Dr. Hagen, a small male of the first form, from Georgia (No. 279), agrees well with Le Conte's description. It has a small branchiostegian spine, overlooked in Hagen's description. The rostrum has no trace of ante-apical spines; the antennal scale is very broad, attaining its greatest breadth in the middle, then narrowing but little until reaching the level of the apical spine. It is a little shorter than the peduncle of the second antennæ, and equal to the rostrum in length. The male appendages are represented on Plate I.

of Hagen's Monograph, figs. 93, 94. This is doubtless Le Conte's species. It is peculiar in having tufts of long hair-like setæ on the inner margin of the hand. The only other species known to have these hair-like growths is *Astacus Gambelii*, from the Western United States, which has the pilosity on the outer as well as the inner margin of the hand.

Length, 42 mm. Carapace, 21 mm. Abdomen, 22 mm. From tip of rostrum to cervical groove, 14 mm. Cardiac region, 7 mm. Width of areola, 1 mm. Length of chela, 14 mm.; breadth of do., 5 mm.

Of the other specimens referred to *C. penicillatus*, two young females from Charleston, S. C. (Cat. No. 254) are surely *C. troglodytes*. Two other females and two males, form II., also from Charleston (Cat. No. 250), may be the female and second form of the male of *C. penicillatus*, as claimed by Hagen, but I suspect that they belong to another species. The form of the first pair of abdominal appendages of the male (Hagen, Pl. I. figs. 95, 96) is not what one would expect in the second form of *C. penicillatus*. The antennal scale is narrower, longer, diminishing more rapidly in width beyond the middle. The lack of beard on the hands, a more gradually tapering rostrum with longer acumen, and the trispinous basal segment of the telson also serve to distinguish these specimens from the first form male from Georgia.

In the collection of Butler University, Irvington, Ind., is a male, form II., collected in Eastern Mississippi by O. P. Hay, which closely resembles the specimen of *C. penicillatus* from Georgia, excepting in the following particulars. The base of the rostrum is more clearly foveolate. The areola is only one half the width of that of *C. penicillatus*, being reduced to such an extent as to admit but one line of impressed dots within its area, while in the Georgian specimen there are two or three parallel longitudinal rows in the narrowest part of the areola. The fore border of the carapace is not angulated behind the antennæ, as in the specimens from Georgia and Charleston. The setæ that grow from the squamous tubercles on the inner edge of the hand are longer than on the other parts, but are not drawn out into pencils, as in the first form from Georgia.

The first pair of abdominal appendages are articulated at the base, recurved at their distal end, though not so strongly as in the first form from Georgia; internal part with a short apical tooth directed obliquely outwards, external part with two stout apical teeth. The short apical tooth of the internal part of the appendage gives it a very different appearance from the second form males from Charleston, described above, and referred to *C. peni-*

cillatus by Hagen, and the two can hardly belong to the same species. The teeth at the tip of the external part are also shorter and blunter in the Mississippi specimen than in those from Charleston. The hooks on the third and fourth pairs of thoracic legs are very small, — mere tooth-like processes. The antennal scale is broad at the tip, as in the Georgia specimen.

Measurements. — Length, 50 mm. Carapace, 25 mm. Abdomen, 26 mm. Rostrum, 5 mm. From tip of rostrum to cervical groove, 16.5 mm. Cardiac region, 8.5 mm. Width of areola, .5 mm. Length of chela, 14 mm.; breadth of chela, 5 mm.

This specimen, as well as those from Charleston, may belong to different species from *C. penicillatus*, but my material is not sufficient to warrant the establishment of new species.

Le Conte does not specify from what part of Georgia his specimens came, nor is the locality of the Georgia specimens in the Museum of Comparative Zoölogy any more precisely indicated.

14. Cambarus Wiegmanni.

Astacus (Cambarus) Wiegmanni, Erichson, Arch. f. Naturgesch., XII. Jahrg., I. 99, 1846.
? *Cambarus Wiegmanni*, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 54, Pl. III. fig. 151, 1870.
Cambarus Wiegmanni, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 138, 1884.

Four species of Cambarus have been described from Mexico; viz. *C. Wiegmanni* Erichs., *C. Mexicanus* Erichs., *C. Azteeus* Saussure, and *C. Montezumæ* Saussure. *C. Wiegmanni* has hooks near the base of the third and fourth pairs of legs of male, tuberculated chelæ, carpus dentated on the inner border. *C. Mexicanus* has only the third pair of legs of the male hooked, chelæ granulated, carpus unarmed. *C. Azteeus* also has the third pair of legs hooked in the male, chelæ granulated, more compressed than in *C. Mexicanus*, carpus armed with some spines within and below. It is doubtful whether this be specifically distinct from *C. Mexicanus*. In *C. Montezumæ* the second and third pair of legs of the male are hooked, the carpus and chelæ smooth. To the list of Mexican Cambari is to be added *C. immunis*, collected at Orizaba by Prof. Sumichrast. An undescribed Parastacine occurs at Colima, on the west coast.

The types of Erichson's two Mexican species of Cambarus, *C. Wiegmanni* and *C. Mexicanus*, could not be found in the Berlin Museum, either by Hagen, who examined the collection in September, 1870, or by Von Martens (Arch. Naturgesch., 1872, p. 131). *C. Wiegmanni* alone of the known Mexican spe-

cies belongs to the *C. Blandingii* group, with hooks on the third and fourth pairs of legs in the male. The female specimen in the Acad. Nat. Sci. Phila. (No. 170, Mr. Pease), fully described by Hagen, is probably correctly referred to this species by him, although in the absence of male specimens there is some uncertainty. It would seem to belong here rather than to *C. Mexicanus*, on account of the tuberculous chelæ and the dentiform tubercles on the inner margin of the carpus.

I have seen but one specimen of *C. Mexicanus*, a male. In this the chelæ are more cylindrical, and are covered with smaller, more closely set, granular tubercles. In the collection of Acad. Nat. Sci. Phila. I find another alcoholic female from Jalapa, Mexico, which agrees well with Mr. Pease's specimen. A mutilated female in the U. S. Nat. Mus. (No. 3288, Prof. Sumichrast), from the Isthmus of Tehuantepec, seems also to belong here.

C. Wiegmanni differs from *C. penicillatus* in the strongly tuberculated chelæ, rostrum narrowing more suddenly before the acumen, and broader areola. Erichson's description is appended. The form of the male appendages is not noticed.

"*A.* (*Cambarus*) *Wiegmanni:* Chelis tuberculatis, digitis æqualibus, carpis intus dentatis, rostro lato, lanceolato.

"Panzerschild punktirt, die Längsleisten an der Schnabelwurzel kurz, etwa bis zur Mitte des dritten Gliedes der äusseren Fühler reichend, der Schnabel breit, lanzettförmig zugespitzt, oben flach ausgehöhlt, mit aufgeworfenem scharfen Rande. Die Fühlerblätter sehr breit, der Aussenrand etwas verdickt, mit überragender Spitze. Die Scheerenbeine ziemlich kurz, die Scheeren länglich, ziemlich schmal, oben und unten gewölbt, mit kleinen Höckerchen etwas weitläufig besetzt, am Innenrande die Höcker dichter und spitzer; die Finger kräftig, gefurcht, in den Furchen punktirt; das Glied vor der Scheere am Innenrande mit einigen Zähnen besetzt. Der Schwanz etwas zusammengedrückt, schmäler als das Panzerschild, nach hinten allmählich etwas verschmälert.

"Das zweite Glied am dritten und am vierten Beinpaar beim Männchen mit einem hakenförmigen Fortsatz.

"Länge des Korpers von der Schnabelspitze bis zum Ende der Schwanzflosse 2″, des Schnabels $2\frac{1}{2}$‴, des Scheerenbeins 1″ 4‴, der Scheere 8‴, Breite derselben fast 3‴, grösste Breite des Panzerschildes 6‴, Hohe desselben ebenfalls 6‴.

"In Mexiko. Von Deppe gesammelt."

15. Cambarus pellucidus.

Astacus pellucidus, Tellkampf, Arch. Anat., Physiol. u. wissensch. Med, 1844, p. 383.
Astacus (Cambarus) pellucidus, Erichson, Arch. Naturgesch., XII. Jahrg., 1. 95, 1846.
Astacus pellucidus, Gibbes, Proc. Amer. Assoc. Adv. Sci., 3d Meeting, p. 195, 1850. (No description.)
Cambarus pellucidus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 87, 1852. (No description.)
Cambarus pellucidus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 55, Pl. I. figs. 68–71, Pl. III. fig. 148, Pl. VI., 1870. — Amer. Naturalist, VI. 494, 1872.
Cambarus pellucidus, Packard, Amer. Naturalist, V. 750, fig. 131 (after Hagen), 1871. — Fifth Ann. Rep. Trustees Peabody Acad. Sci. for the Year 1872, p. 94, 1873.
Orconectes pellucidus, Cope, Amer. Naturalist, VI. 410, 419, 1872. — Third and Fourth Ann. Rep. Geolog. Surv. Indiana, pp. 162, 173, 1872.
Orconectes inermis, Cope, Amer. Naturalist, VI. 410, 419, 1872. — Third and Fourth Ann. Rep. Geolog. Surv. Indiana, pp. 162, 173, 1872.
Cambarus pellucidus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (No description.)
Cambarus pellucidus, Putnam, Proc. Boston Soc. Nat. Hist., XVII. 222, XVIII. 16, 1875. (Habits.)
Cambarus pellucidus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 139, 1884.

Known Localities. — Kentucky: Mammoth Cave and other caves in Edmonson Co. Indiana: Wyandotte Cave, Crawford Co.; cave in Bradford, Harrison Co.

The earliest notice of the blind crayfish of the Mammoth Cave occurs in the Proceedings of the Academy of Natural Sciences of Philadelphia, Vol. I. p. 175. In the record of the meeting of the Academy on May 24, 1842, the donation of a specimen is thus acknowledged: "A white eyeless crayfish (*Astacus Bartoni*?) . . . . from the Mammoth Cave, Kentucky, about 2½ miles from the entrance. Presented by W. T. Craige, M. D."

From a "Notice of the Blind Fish, Crayfish, and Insects from the Mammoth Cave, Kentucky," communicated by William Thompson to the Annals and Magazine of Natural History (Vol. XIII. p. 111, February, 1844), I quote the following: —

"At a meeting of the Belfast Natural History and Philosophical Society, Jan. 17, 1844, Mr. Thompson, the President, called attention to specimens of the Blind Fish, Crayfish, and Locusts from the great Mammoth Cave in Kentucky, procured in the month of May last, specially for the Society, by the kind attention of our townsman, Gordon A. Thomson, Esq., on his visit to the cave. They are perhaps the first examples of their respective species brought thence to Europe.

"The cave itself is popularly known from having been described in 'Chambers's Edinburgh Journal' for 1838, Vol. VI. p. 234; and more recently, at least in this town, from a letter by the Rev. Wm. Murphy, St. Mary's

College, Kentucky, published in the 'Belfast Commercial Chronicle' of Jan. 1, 1844, where it occupies two columns, but the source whence it was obtained is not acknowledged. . . . . The crayfish and 'crickets' are stated in the letter already noticed [the Rev. Wm. Murphy's ?] to be blind, but this is erroneous. Both species have eyes. Our specimen of the crayfish wants both the claws, but is otherwise perfect, and agrees with the description of the *Astacus Bartoni* Fabr., given in Milne Edwards's 'Histoire des Crustacés,' Vol. II. p. 331. The length there attributed to the species is 3 inches; the specimen before us is $2\frac{1}{4}$ inches in length from the point of the rostrum to the extremity of the caudal plates."

The description of *Astacus Bartonii* by Milne Edwards, here referred to, is in reality a description of *Astacus affinis* Say; but as *C. Bartonii* is the only eyed crayfish known to inhabit the Mammoth Cave, it was probably the species in Thompson's hands. Tellkampf's type (a male, form I.) was more fully described by Erichson, and was seen by Hagen in the Berlin Museum in September, 1870.

The presence in the Mammoth Cave of a crayfish with well-developed eyes, together with the blind species, was noticed by Prof. B. Silliman, Jr., in 1850. In a letter to Professor Guyot, dated Louisville, Nov. 8, 1850, printed in the American Journal of Science and Arts, 2d Ser., Vol. XI., May, 1851, he says (p. 336): —

"The crawfish, or small crustacea inhabiting the rivers with the fish, are also eyeless and uncolored, but the larger-eyed and colored crawfish, which are abundant without the cave, are also common at some seasons in the subterranean rivers. . . . . Among the collections are some of the larger-eyed crawfish which were caught by us in the cave."

I have now before me specimens of *C. pellucidus* and *C. Bartonii* from the Peabody Museum of Yale College (Nos. 1814, 1815), collected by Professor Silliman in the Mammoth Cave. More recently, *C. Bartonii* has been frequently captured there.

The association of *C. pellucidus* and *C. Bartonii* in the Mammoth Cave, and the fact that cave specimens of the latter are often very light colored, led Professor N. S. Shaler* to conclude that the two species were connected by transitional forms, and that the blind form was derived from the present outside fauna of the region. He even goes so far as to suppose that the blind form, *C. pellucidus*, is continually reinforced by interbreeding with the

* Mem. Boston Soc. Nat. Hist., II. 362, 363, 1875.

eyed form derived from without the cave! But as we have seen (see p. 18), *C. pellucidus* is a very aberrant species, with no very closely related form outside the cave. The simple form of the male appendages, and the combination of characters belonging to different groups,* seen in *C. pellucidus*, indicate, to my mind, that it is a very ancient form, which has been preserved in the seclusion of the cave, while its nearest kin succumbed in the sharper struggle incident to life outside, or were replaced by modified descendants evolved to meet the changeable conditions which obtain without the caverns. This view is rendered more probable when one remembers that the same form, *C. pellucidus*, occurs in the Wyandotte Cave on the other side of that ancient river, the Ohio. The transportation of an eyeless cave species from the Kentucky caverns to those of Indiana seems out of the question, and one is driven to the conclusion that the subterranean waters of both localities derived this eyeless species from a similar form with well-developed eyes, that peopled the streams throughout this region at a remote period. Further, if we trust the statements of Gustav Joseph (see p. 45), a Cambarus is found in the caves of Carniola in Southern Austria very closely related to *C. pellucidus*, while all the European crayfishes else belong to another genus, Astacus. That the similarity of conditions affecting cavern life in all parts of the world is sufficient to bring about the close agreement between the crayfishes of the caves of Carniola and Kentucky, when the forms outside the caves belong to different genera in the two localities, seems highly improbable. The genus Cambarus in North America has not originated under the influences of subterranean life, but is the ordinary form of crayfish throughout the whole of the eastern and central portions of the continent. If the cave species of Carniola were derived from the present outside fauna of Europe, we should have a blind Astacus instead of a blind Cambarus. I am rather inclined to accept the Carniola cave species as a witness to the former existence of the genus Cambarus in the rivers of Europe (see p. 176).

C. pellucidus is subject to considerable variation. In some specimens the rostrum is shorter than in typical specimens, and contracts more from the base to the lateral teeth, which are much less prominent. The spines of the postorbital ridge and sides of the carapace are slightly developed. This is the form described as a new species, *Oreonectes inermis*, from Wyandotte Cave, Indiana, by Prof. Cope, in 1872. I owe to Prof. A. S. Packard

* With the essential characters of Group I. are found the general form of body of the species belonging to Group III. and the rostrum of Group IV. The antennal scale dilated near the tip is characteristic of Groups III. and IV., rather than of Group I.

an opportunity to examine Cope's type. It is a male, form II., with the first pair of abdominal appendages not articulated, a condition often found in the second form males of this species. After an examination of this specimen, I can indorse the opinion of Hagen (Amer. Nat., Aug., 1872) and Packard (Fifth Ann. Rep. Peabody Acad. Sci., for 1872), expressed before seeing the specimen, that the variation is not of specific value. All the specimens which I have seen from the Indiana caves, amounting to six in number, belong to this form. But the same form also comes from the Mammoth and neighboring caves in Kentucky. In a gigantic female in the Museum of Comparative Zoölogy (No. 3417, collected in Mammoth Cave by F. W. Putnam), the peculiarities of Cope's form are intensified. The point of the rostrum does not reach the distal end of the peduncle of the antennule, and hardly attains the proximal end of the distal segment of the peduncle of the antenna.* The lateral rostral spines are reduced to salient angles. The post-orbital ridges are destitute of spines, as in *C. Bartonii*. The antennal scales reach but to the proximal end of the terminal segment of the peduncle of the antenna. The lateral spinules of the carapace are represented by granular tubercles. The spines of the meros of the cheliped are short and tooth-like; those on the upper surface are blunt, those beneath are irregularly disposed, without the clear biserial order seen in the typical form, and also in Cope's type of *O. inermis*. The hands are broad, flattened, and tuberculate.

In this specimen, moreover, the anterior process of the epistoma is truncated in front. The dimensions are subjoined. Length of body, 93 mm.; of carapace, 46 mm.; of rostrum (from level of post-orbital spines to tip), 9 mm.; of abdomen, 49 mm.; from tip of rostrum to cervical groove, 26 mm.; from cervical groove to posterior margin of carapace, 20 mm. Length of cheliped, 84 mm.; of chela, 43 mm.; of antenna, 86 mm.; of antennal scale, 8 mm.

The other blind *Cambarus* from the United States (*C. hamulatus* from Nickajack Cave, Tenn.) resembles *C. pellucidus* superficially, but belongs to Group III., with hooks only on the third pair of legs in the male. The first pair of abdominal appendages are very different from those of *C. pellucidus*, being formed after the pattern of those organs in *C. Bartonii*. The annulus ventralis of the female is also different.

A small specimen of *C. pellucidus* was found in a jar containing *C. Putnami* from Green River, near the Mammoth Cave, collected by Mr. F. W. Putnam.

* In the typical form of *C. pellucidus* the rostrum equals or exceeds in length the peduncle of the antenna.

So it would seem that the blind species sometimes finds its way out from the cave.

The blind fishes of the Mammoth Cave are compensated for the loss of sight by the development of special tactile papillæ. Among the Crustacea the eyeless *Gammarus pulcanus* and *Asellus cavaticus* are more richly furnished with olfactory setæ than are their relatives that enjoy the sense of sight. In the Astacidæ the setæ to which Leydig has ascribed an olfactory function are borne by the outer flagellum of the antennules. Leydig * has described their arrangement in *C. pellucidus*. The outer flagellum is composed of about thirty-six segments. The olfactory setæ are situate for the most part on the distal half of the flagellum, beginning with the fifteenth segment, the number of setæ on each segment decreasing toward either extremity of the olfactory portion of the flagellum. Leydig was unable to compare *C. pellucidus* with any of the species of Cambarus possessed of eyes, but he observed that the antennulary flagella of *Astacus fluviatilis* were shorter and contained fewer segments than in *C. pellucidus*. This, however, is a generic distinction, and cannot be brought into relation with the absence of visual organs in the cave species.

Professor R. Ramsay Wright † has followed up Leydig's suggestion by a comparison of the so-called olfactory organs of *C. pellucidus* with those of the eyed *C. propinquus*. He finds that the external flagellum of the antennule of the latter species is composed of eighteen or nineteen segments, the distal nine of which alone bear olfactory setæ. He therefore concludes that *C. pellucidus*, like the blind Gammarus and Asellus, has acquired a more complete olfactory apparatus in compensation for the loss of sight.

I have examined several specimens of *C. propinquus* with reference to this point, and find that the number of segments in the external flagellum of the antennule may be as high as thirty-five, fifteen or sixteen of which may carry olfactory organs. In *C. affinis* I have counted as many as thirty-three segments in the flagellum, nineteen with olfactory setæ. A moderate-sized *C. Blandingii* from New Jersey reveals about fifty segments, twenty-nine of them provided with olfactory setæ. It thus appears that Professor Wright's conclusion, that the number of antennulary segments and olfactory organs is increased in the blind species, is not supported by the facts. It is noteworthy, however, that the olfactory setæ of *C. pellucidus* are longer

* Untersuchungen zur Anatomie und Histologie der Thiere, p. 38.

† American Naturalist, Vol. XVIII p. 272, March, 1884.

than in most species of Cambarus. In a specimen of *C. hamulatus*, the other blind cave species, there are thirty segments in the outer flagellum of the antennule, and the olfactory setæ are long, as in *C. pellucidus*.

Cambarus typhlobius.

Cambarus Stygius, Joseph, Berliner Entomolog. Zeitschr., XXVI. 12, April, 1882. (Name preoccupied by Bundy.)

The earliest notice of the existence of a blind crayfish, closely resembling *Cambarus pellucidus*, in the caves of Carniola, is in the 57th Jahresbericht der Schlesischen Gesellschaft für vaterländische Cultur, 1879, p. 202, Breslau, 1880. It is there recorded that Dr. Gustav Joseph "demonstrirte einen neuen, 9 cm. langen, zur Familie der Astaciden gehörigen blinden Grottenkrebs aus Krain, welcher der aus der Mammuthshöhle von Kentucky in Amerika bekannten Art (*Cambarus pellucidus* Tellkampf) sehr nahe steht und deshalb vom Vortragenden *Cambarus typhlobius* n. sp. benannt worden ist."

In a paper published in December, 1881, in the twenty-fifth volume of the Berliner Entomologische Zeitschrift,* the same writer mentions, without describing, the animal, under the names *Cambarus cæcus* n. sp. (p. 237) and *Cambarus Stygius* n. sp. (pp. 241, 249).

In the twenty-sixth volume of the same journal, pp. 12–14, April, 1882,† a fuller account of the animal is given by Dr. Joseph. On account of the importance of the discovery, and the rarity of the Berlin Entomological Journal in America, I transcribe the entire description.

"*Cambarus Stygius*, n. sp.

"Wie *Anophthalmus Tellkampfii* Erichs. aus der Mammuth-Höhle bei Kentucky der nächst Verwandte des Krainer *A. Schmidtii* Sturm, so erscheint *Cambarus Stygius* mit dem amerikanischen *C. pellucidus* Tellkampf aus der genannten Höhle sehr nahe verwandt. In der Sammlung von Ferdinand Schmidt in Ober-Schiska bei Laibach befand sich zur Zeit ein getrockenes Exemplar dieser von mir entdeckten Krebsart, das aus der Grotte von St. Kanzian stammte und mit dem Namen '*Astacus saxatilis*' (?) bezeichnet war. Reste von Scheeren fand ich im Darm eines Olm, der in einer Höhle bei Gabroviza oberhalb Triest gefunden sein soll. Nachträglich wurde mir mitgetheilt dass in der Höhle von Ospo unweit Triest ein grosser, dem Flusskrebs ähnlicher, Krebs vorkommen soll. Die Exploration derselben im September 1881 in Begleitung des Herrn Dr. Graeffe, Inspector der Kais. Königl. Zoolog. Station in Triest, hatte aber ein negatives Resultat. Das Exemplar meiner Sammlung, welches ebenfalls aus dem Reccafluss aus der Grotte von S. Kanzian bei Metaùn unweit Divazza stammt, ist ein geschlechtsreifes Männchen, das an Grösse die amerikanische Art nach der von Packard ('The Mammoth Cave and its Inhabitants'. . . .) veröffentlichten Abbildung kaum übertrifft. Trotz aller Mühe gelang es mir bisher nicht mir ein Exemplar der amerikanischen Art Behufs Vergleichung zu verschaffen. Leider stand mir auch nicht die Abbildung, welche Tellkampf und Hagen

* "Erfahrungen im wissenschaftlichen Sammeln und Beobachten der den Krainer Tropfsteingrotten eigenen Arthropoden von Dr. Med. et Phil. Gustav Joseph, Docenten a. d. Universität Breslau."

† "Systematisches Verzeichniss der in den Tropfsteingrotten von Krain einheimischen Arthropoden nebst Diagnosen der vom Verfasser entdeckten und bisher noch nicht beschriebenen Arten."

von diesem grössten aller Grottenkrebse geben, zu Gebote, während die von Packard publicirte nicht detaillirt genug ist, um bei Vergleichung die nöthige Sicherheit zu gewähren. Von der Spitze des Rostrum frontale bis zur Schwanzflosse misst das (7 Jahr in Spiritus aufbewahrte) Thier 6.5 cm. Die lateralen grossen Fühler sind um $\frac{1}{10}$ länger als bei der amerikanischen Art. Die Basis der innern Fühler ragt weiter als das Rostrum nach vorn, während bei der amerikanischen Art Nichts davon zu sehen ist. Während in der Packard'schen Abbildung die Augäpfel nicht wahrnehmbar sind, erscheinen dieselben bei dem Krainer Exemplar ebenso deutlich wie bei *Troglocaris Schmidtii*, aber statt der Hornhautfacetten besteht das Integument des Augapfels wie des Augenstiels aus undurchsichtiger Chitinhaut. Ebenso fehlen wie bei dem blinden Cariden jegliche lichtbrechende und lichtempfindende Elemente. Der Augapfel ist erfüllt von derber bindegewebiger, mit Fett durchsetzter Masse. Durch den Augenstiel zieht ein bindegewebiger Streif in der Richtung gegen das obere Schlundganglion hin, Befunde, wie ich sie bereits seit länger als einem Jahrzehnt bei *Troglocaris Schmidtii* gefunden und veröffentlicht habe. Indem ich mir die Abbildung und genaue Beschreibung für eine grössere Arbeit über die Gesammtfauna der Krainer Grotten vorbehalte, will ich nur noch folgende, im Vergleich zur wahrscheinlich mangelhaften Packard'schen Abbildung der amerikanischen Art höchst auffallende, Unterscheide hervorheben. Von dem 2. Gliede des 3. Schreitfusses ragt ein hakenförmiger Auswuchs von $\frac{1}{3}$ der Grösse dieses Gliedes schief nach vorn und (proximalwärts) medialwärts; ebenso von entsprechender Stelle am 4. Schreitfuss ein ähnlich gestalteter aber kürzerer und schmächtiger. Das 1. Paar der Schwimmfüsse ist in ähnlicher Weise zu Begattungsorganen umgebildet, wie bei dem Flusskrebs; das 2. Paar ist im Endgliede membranös und tief gespalten."

From this imperfect description it appears that the peduncle of the antennule is longer in proportion to the rostrum than in the typical *C. pellucidus*, and the eye larger. Whether this species conforms to the genus Cambarus in the number and arrangement of the gills, we are not told; but the presence of hooks on the third and fourth pairs of legs seems to indicate a true Cambarus.*

As the name *Cambarus Stygius* was employed by Bundy, in 1876, for an American species, I have adopted the name suggested by Joseph in his first notice of this species.

It is to be lamented that a fuller account of this animal has not been published, on account of its important bearings on the subject of the geographical distribution of these animals. Remarks on the meaning of the presence of this Cambarus in the caves of Carniola, the sole representative of the genus in the Eastern continent, will be found on pp. 42, 176.

Cambarus Stygius.

Cambarus Stygius, Bundy, Bull. Ill. Mus. Nat. Hist., No. 1. p. 3, 1876. — Trans. Wis. Acad. Sci., V. 180, 1882. — Geol. Wis., Surv. 1873–1879, I. 402, 1883.
Cambarus Stygius, Forbes, Bull. Ill. Mus. Nat. Hist., No. 1. p. 19, 1876. (After Bundy.)

"Rostrum long and pointed, smooth above, foveolate at base, cephalothorax slightly compressed, smooth or slightly punctate above, finely granulate on sides; areola narrow; lateral spine acute; antennal plates wide, truncate, with short apical teeth; epistoma

* I presume that Joseph's statement, that the hooks spring from the second segment of the leg in the Carniola species, is an error, since these processes are always found on the third segment.

rounded in front, twice as wide as long; third maxillipeds hairy on inner and lower aspects; chelæ short, smooth above, serrate on interior margins; fingers short, nearly straight, costate and punctate above, contiguous margins tuberculate, exterior one hairy; third joint of third (and fourth ?) thoracic legs of male hooked. (Of three males sent me by Dr. P. R. Hoy, not one had the fourth thoracic legs remaining.)

"First abdominal of male short, truncate, with three short, obtuse teeth directed outward from the posterior margin at apex. A smooth groove passes up on the outside of the leg between these teeth and the anterior margin.

"Ventral annulus of female flat, transversely elliptical, posterior margin slightly elevated.

"This species is closely related to *C. acutus*, but may be at once separated by the shorter hands — similar to those of *C. propinquus* — and the non-tuberculated annulus of female.

"Found by Dr. P. R. Hoy on the shores of Lake Michigan [at Racine, Wis.], having been washed ashore during a storm." — Bundy, Geol. Wis., Vol. I. p. 402.

Color, "dark cream, darker along the sutures."

This species is known to me only through the descriptions of Bundy. In his earlier description, in the Bulletin of the Illinois Museum of Natural History, he states that the rostrum has "small teeth near apex," and that the carinæ are "parallel, separated from base of rostrum by slight grooves." In this description it is said that the "third and fourth joints of third thoracic legs" are hooked. This is probably a printer's error for the "third joint of third (and fourth ?) thoracic legs of male hooked" of the later description. Misled by this typographical (?) error, Forbes, in his synopsis of the species mentioned in the paper in the Bulletin of the Illinois Museum of Natural History, places this species with *C. gracilis* in the group with hooks only on the third pair of legs. The "outer margin of finger hairy," of Forbes's diagnosis, seems to show a misconception of Bundy's description, which undoubtedly means *inner margin of outer finger hairy.*

GROUP II. (Type C. advena.)

Third segment of third pair of legs of male hooked. First pair of abdominal legs of male similar to those of Group I.

The species of this group seem to form the passage from Group I. to Group III. (*C. Bartonii*). The first pair of abdominal appendages of the male are similar to those of the species in the *C. Blandingii* group, being truncate at the tip, the outer part terminating in one or two short tubercles or teeth, the inner part in a short, erect spine. Only the third pair of legs of the male are hooked. *C. simulans*, *C. Mexicanus*, and *C. Cubensis* resemble in their general form and shape of chela the species included in Group I. The chela and antennal scale of *C. simulans* are much as in *C. Blandingii*, var. *acuta*. In *C. Mexicanus* and *C. Cubensis* the chela is sub-cylindrical and slender, and covered with small ciliated squamous tubercles. *C. advena*,

C. Carolinus, and *C. gracilis* resemble *C. Diogenes* of Group III. in the general form of body, linear areola, small antennal scale, broad chela, etc. The fore border of the carapace is angulated behind the antennæ in *C. simulans*, *C. Mexicanus*, *C. Cubensis*, and *C. gracilis;* not angulated in *C. advena* and *C. Carolinus*. The rostrum is armed with small lateral teeth in *C. Cubensis;* in the other species of this group the rostrum has no lateral teeth.

Of the species belonging to this group, Hagen knew only *C. advena* and *C. Carolinus*. These were placed by him, as aberrant forms, in Group III. (*C. Bartonii*).

- Rostrum with small lateral teeth, areola broad. *C. Cubensis.*
- Rostrum without lateral teeth.
  - Areola of moderate width. Chelæ subcylindrical. *C. Mexicanus.*
  - Areola narrow. Antennal scale large and broad. *C. simulans.*
  - Areola linear, or obliterated in the middle.
    - Front margin of carapace angulated behind antennæ. *C. gracilis.*
    - Front margin of carapace not angulated. *C. advena, C. Carolinus.*

16. Cambarus simulans.

Plate I, fig. 2, Plate VIII, figs. 3, 3', 3 a, 3 a'.

Cambarus simulans, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 112, 1884.

Male, form I.—Rostrum broad, deeply excavated; margins raised into sharp crests, which overhang the base of the sides of the rostrum, converging, situated before the tip to form the short acumen; no lateral spines; the acumen is barely margined. Post-orbital ridges subacute in front, divergent and ending in slight callosities behind. Carapace ovate, narrowing in front, gastric area smooth, cardiac area lightly punctate, sides granulate; anterior border notched behind the antennæ; cervical groove sinuate, split on the sides, with a minute terminal branchiostegian spine; no lateral spine; areola more than one half as long as the distance from the point of the rostrum to cervical groove, narrow, carinate, expanding into an anterior and a posterior triangular field; two longitudinal dotted lines run along the areola from the anterior triangle to the posterior triangle, which is irregularly and sparsely dotted. Abdomen broad, shorter than carapace, punctate, posterior margins of pleura obliquely convex; hind margin of anterior segment of telson bi- to multi-denticulate on each side, posterior segment short, hind border almost straight; median rib of inner plate of swimmeret ends inside of the margin. Basal segment of antennule with a spine below. Antennæ shorter than

body, second and third segments furnished with minute blunt spinules, scale a trifle longer than the rostrum, very broad, broadest in the middle, truncate at apex, external terminal spine minute. Anterior process of the epistoma triangular, antero-lateral borders convex, rimmed, anterior angle truncate or notched in old specimens, with a projecting median spine. Third maxillipeds densely hairy within and beneath. Chela long, slender, squamoso-tuberculate, internal margin long, straight, strongly dentate; fingers long, punctate, external border of movable finger tuberculate, inner border of both fingers toothed, a prominent tubercle near the base of external finger opposite a more or less clearly marked incision in the base of the thumb. Carpus triangular, obliquely truncate, inner margin armed with a stout spine and some low, scattered tubercles, lower side with two or three teeth and numerous small tubercles. Superior margin of meros with short spines, which are sometimes obsolescent except the distal ones; below, the biserial spines are well developed. Sternum hairy. Third pair of legs hooked. First pair of abdominal appendages strong, straight, internal part with a very small, straight apical spine, which does not reach the end of the external part; external part with two horny terminal teeth, one of which is flat and disk-shaped, the other slender and somewhat curved.

Length, 97 mm. Breadth, 27 mm. Length of carapace, 51 mm. Length of areola, 18 mm. Width of areola, 1.3 mm. Length of rostrum, 11.5 mm. Length of chela, 50.5 mm.

Male, form II.—Chelipeds smaller, hooks on the third pair of legs smaller, first abdominal appendages without horny teeth at apex.

Female.—Chelæ smaller and shorter-fingered than in the male; annulus ventralis bituberculate in front, each tubercle denticulate.

Known Localities. — Texas: Dallas; east of Canadian River (Coll. U. S. Nat. Mus.). Kansas: Fort Hays.

This species is remarkable in having the general form of body and claw of the *C. Blandingii* group of species, while the fact that only the third pair of legs are hooked places it in the *C. advena* group. The male appendages and the female annulus are very near to those of *C. gracilis*. In the shape of the body, areola, antennal scale, and claw, it resembles *C. Blandingii*, var. *acuta*, but the rostrum is deeply excavated, and toothless even in small specimens. The full cephalothorax and large abdomen seem to indicate that it is not a pre-eminently burrowing species, like its allies, *C. gracilis*, *C. advena*, etc.

There are specimens in the United States National Museum collected by

the United States Exploring Expedition West of the Hundredth Meridian in pools east of the Canadian River. This locality, I presume is within the limits of the State of Texas.

17. Cambarus Mexicanus.

Astacus (*Cambarus*) *Mexicanus*, Erichson, Arch. Naturgesch., XII. Jahrg., I. 99, 1846.
? *Cambarus Aztecus*, Saussure, Rev. et Mag. de Zool., 2e Sér., IX. 503, 1857. — Mém. Soc. Phys. Hist. Nat. Genève, XIV. 460, Pl. III. fig. 23, 1858.
Cambarus Mexicanus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 84, 1870. (After Erichson.)
Cambarus Mexicanus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 141, 1884.

Male. — Rostrum sub-plane, margins raised into crests gradually converging until within a short distance of the tip, where the crests become obsolete and the margins of the rostrum suddenly converge, without lateral spines, to form the short-pointed acumen. Post-orbital ridges parallel, obtuse in front. Carapace laterally compressed, of nearly equal width throughout, thickly punctate, sub-orbital angle rounded, cervical groove sinuate, no lateral spine, branchiostegian spine small, blunt; areola narrow, punctate. Abdomen as long and broad as the cephalothorax, telson with three or four small spines on each side, posterior segment short. Antennal scale broad, broadest in the middle. Chela long, subcylindrical, thickly beset with squamous ciliated granules; fingers about the same length as the hand, ciliate, granulate, costate. Carpus hardly sulcate above, covered with granules like the hand; no teeth on the inner margin. Meros granulate, outer surface smooth except on the margins and distal end; a biserial row of spines below. Third pair of legs hooked. Sternum setose. First pair of abdominal appendages short, straight, a rectangular shoulder on the anterior margin near the tip, external and internal parts in close apposition to their tips; external part furnished with a small, slender, procurved, horny spine; internal part flattened within, apex straight, scarcely separated from external part.

Length, 51 mm. Carapace, 25 mm. Length of areola, 8 mm.; width of areola, 0.6 mm.

The above description is drawn up from a specimen in the Academy of Natural Sciences of Philadelphia, received from Mirador, Mexico, through Dr. Sartorius. The hooks on the third pair of legs are well developed, the first pair of abdominal appendages not articulated. I think there is no doubt that this specimen is Erichson's *C. Mexicanus*, the types of which could not be found in the Berlin Museum either by Dr. Hagen or Von Martens.

Cambarus Aztecus, as described and figured by Saussure, has a shorter, flatter hand, and carpus spinous on internal border.* Von Martens (Arch. Naturgesch., XXXVIII. Jahrg., I. 131) would separate it from *C. Mexicanus*. Dr. Hagen has kindly given me the following note on the types of Saussure in the Berlin Museum, which he examined in September, 1870.

"The first form of the male and the female, from Mexico, seem to be *C. Mexicanus* Erichs., with nearly cylindrical hands. The second form, with more flattened hands, belongs alone, then, to Saussure's *C. Aztecus*. In the second form the antennal scale is more broadly truncate in front, and the rostrum is a little different, but these differences are not striking enough to preclude the identity."

A sketch of the first form male appendages, made from one of these types by Dr. Hagen, shows them to be of the same form as in the specimen I have described above.

The female specimens noticed on page 39 under *C. Wiegmanni* have a shorter and broader chela and carpus, the granules on the internal margin of the carpus assuming the character of spinules. As there are no male specimens among them, I am not sure that they are not the female of *C. Aztecus* Saus.; but this point, as well as the identity of *C. Aztecus* and *C. Mexicanus*, I must leave unsettled for lack of material.

Saussure's locality for *C. Aztecus* is, "Les ruisseaux du Mexique. — Pris à Tomatlan, dans les Terres-Chaudes." According to Von Martens (Arch. Naturgesch., XXXVIII. Jahrg., I. 130) there are specimens in the Berlin Zoölogical Museum from Puebla.

18. Cambarus Cubensis.

Plate II. fig. 1, Plate VIII. figs. 5, 5, 5a, 5a'.

Astacus (Cambarus) Cubensis, Erichson, Arch. Naturgesch., XII. Jahrg., I. 100, 1846.
? *Cambarus consobrinus*, Saussure, Rev. et Mag. de Zool., 2e Sér., IX. 101, 1857. — Mém. Soc. Phys. Hist. Nat. Genève, XIV. 457, Pl. III. fig. 21, 1858.
Cambarus Cubensis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 85, 1870. (After Erichson.)
Cambarus Cubensis, Von Martens, Arch. Naturgesch., XXXVIII. Jahrg., I. 129, 1872.
Cambarus Cubensis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 142, 1884.

Male, form I.—Rostrum triangular, moderately excavated, acumen short, acute, small lateral teeth at base of acumen. Anterior end of post-orbital

* "*Cambarus Aztecus*. Rostre court, arrondi au bout. Carènes latérales obtuses, ne se terminant pas en une épine. Carapace ponctuée, granuleuse sur les côtés, à sa portion antérieure, mais sans épines au bord du sillon oblique. Mains médiocres ou petites, comprimées, fortement granuleuses et écailleuses; carpes écailleux, armés de petites épines, en dessous, une double rangée d'épines. Pattes de la troisième paire, chez le mâle, armées, à leur base, d'une apophyse rudimentaire. Long., 2 pouces. — Mexique." — Saussure.

spines acute. Carapace laterally compressed, punctate, fore border slightly angulated behind the antennæ; cervical groove sinuate; no lateral spine; small branchiostegian spine; areola of moderate width, punctate. Abdomen longer than the cephalothorax; anterior segment of telson with two to five spines on each side. Epistoma very short, broad, with an anterior spine. Antennæ long, slender; scale very broad, broadest in the middle, with very small apical spine. Third maxillipeds hairy within. Chela sub-cylindrical, long, slender, densely covered with ciliate, squamous, small tubercles; fingers slender, with an internal and external longitudinal rib. Carpus cylindroidal, hardly furrowed above, squamoso-tuberculate like the hand, one or more of the tubercles on the inner margin spiniform. Meros granulate, with spines on the lower surface and at the distal end of superior border. Sternum lanuginose. Third pair of legs with a long, slender hook on the third joint. First pair of abdominal appendages short, thick, outer part ending in a blunt tubercle, bearing a minute horny tooth directed forwards; the internal part projects far beyond the hind border of the external part, terminating in a slender outwardly directed spine; within, it forms a broad, flat, setose plate; the anterior margin of the appendage has a projecting rectangular shoulder near the tip.

The second form of the male has the hooks on the third legs short and blunt; the external part of the first abdominal appendages has a terminal blunt tubercle in place of the sharp horny tooth of the first form.

The female has shorter, broader, smoother hands; annulus composed of a large anterior bilobed tubercle and a smaller posterior tubercle. In a large number of the females examined the annulus is hardly at all developed.

Length, 56 mm.

Habitat. — Cuba.

Erichson does not describe the male appendages, but Von Martens asserts that in Erichson's types in the Berlin Museum these organs have the same structure as in those described by himself as *C. Cubensis* from Gundlach's Cuban collections: "Die ersten Abdominalfüsse sind eigenthümlich gebildet; obwohl nur aus einem Stück bestehend, lassen sich doch gegen ihr Ende zu zwei mit einander verwachsene Theile unterscheiden, ein äusserer, der in eine stumpfe Spitze endigt und dessen Vorderrand nahe derselben merklich anschwillt, und ein innerer, welcher nach hinten den vorigen überragt, nach innen eine ebene ovale Fläche bildet, welche sich an die des Anhangs der vordern Seite anlegt, und an seinem Ende zwei Lappen zeigt,

einen an das Ende des äussern Theils angelegten und einen zweiten kürzeren frei nach vorn vorstehenden, mehr abgerundeten."

It is exceedingly difficult to elucidate the complex structure of these appendages without the aid of figures; but I think there is no doubt that Von Martens's description appertains to the species described above by myself, from specimens collected by Mr. S. Garman near Havana.

Saussure's types of *C. consobrinus*, also in the Berlin Museum, were examined by Hagen in 1870, and by Von Martens. They consist of two dry female specimens. The acumen of the rostrum is longer than in Erichson's species, and it would seem from Saussure's figure that the lateral spines are more prominent. Saussure mentions a small lateral spine, sometimes obsolete, on the carapace, which does not appear in any of the specimens in the Museum of Comparative Zoölogy. In some of the second form males in the latter collection the chelæ are smaller and comparatively smooth, as Saussure says was the case in some specimens of his *C. consobrinus:* "Souvent les pattes de la premiĕre paire sont petites et presque sans caractères, les doigts sans carènes, ponctués au lieu d'être tuberculeux. (Ceci se voit surtout chez les mâles.)" The statement of Saussure, that the *second* joint of the third pair of legs is hooked, is undoubtedly an error for *third* joint. As the male abdominal appendages are not described by Saussure, it is doubtful whether his species be the same as Erichson's. According to Von Martens, specimens in the Berlin Museum make it probable that a second species of Cambarus inhabits the island of Cuba, — a species with a rostrum like *C. Cubensis*, but different sexual appendages.

C. Cubensis finds its nearest kin in *C. Mexicanus*. It is distinguished from that species by its wider areola and toothed rostrum. The male appendages are similar in form, but the inner part is broader, forming a large oval plate. The specimens obtained by Mr. Garman were found in creeks in a little town opposite Havana. According to Saussure, *C. consobrinus* inhabits stagnant pools in Cuba.

The *Astacus fluviatilis major* of Sloane's Jamaica, Vol. II. p. 271, Pl. 245, fig. 2, is a Palæmon, and it is probable that the "common crawfish" of the same author is also a fresh-water prawn. I have seen a specimen of *C. affinis* in the Philadelphia Academy's collection, labelled, "Santo Domingo, W. M. Gabb," but no doubt the locality is erroneous. The only authentic West Indian Cambari are those found in the island of Cuba.

19. Cambarus advena.

Astacus advena, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 402, 1855.
Cambarus Carolinus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 87, Pl. I. figs. 51–54, Pl. III. fig. 165, 1870.
Cambarus advena, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III., Pl. III. fig. 164, Pl. VII., 1870.
Cambarus advena, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 140, 1884.

There is a female type specimen of Le Conte's *Astacus advena* in the Museum of Comparative Zoölogy, and another, also a female, in the collection of the Academy of Natural Sciences of Philadelphia. By some error Dr. Hagen transposed the descriptions of *C. advena* and *C. Carolinus* in his Monograph, so that his descriptions do not agree with his own types of these species in the Museum of Comparative Zoölogy! He gives, under the name of *C. advena*, a full figure of Le Conte's species on Plate VII., and the antennal scale, spine of the second segment of the antenna, and epistoma (from Le Conte's type in the Philadelphia Academy) on Plate III. fig. 164. The male appendages, antennal scale, and epistoma are figured on Plate I. figs. 51–54, Plate III. fig. 165, as *C. Carolinus*.

"Habitat in Georgia inferiore. Hyeme vitam degit subterraneam. Æstate in fossis invenitur." (Le Conte.)

The type of Le Conte in the Museum of Comparative Zoölogy has a spine on the lower side of the first segment of the antennules, as in *C. Carolinus*.

20. Cambarus Carolinus.

? *Astacus* (*Cambarus*) *Carolinus*, Erichson, Arch. Naturgesch., XII. Jahrg., 1. 96, 1846.
Cambarus advena, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 86, Pl. I. figs. 90–92, 1870.
Cambarus Carolinus, Hagen (as determined by examination of his type specimen!).
Cambarus Carolinus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 140, 1884.

For the transposition of the descriptions and part of the figures of *C. Carolinus* and *C. advena* in Hagen's Monograph, see above. Hagen's types of these two species in the Museum of Comparative Zoölogy are correctly determined. The larger dimensions given by Hagen (p. 86), 2.9 in., are those given by Le Conte for *Astacus advena*.

Hagen's type, labelled "*Cambarus Carolinus* Er.," and described by him (p. 86) as *Cambarus advena* LeC., is a male of the first form (M. C. Z., No. 232) from Charleston, S. C. It differs from *Astacus advena* LeC. as follows. The rostrum is less triangular and less deflexed, the cephalothorax more

compressed from side to side, the carapace less granulate on the sides, more sparsely punctate; the branchial regions are more closely appressed, so that they bulge upwards on each side of the areolar line, which thus comes to lie in a depression in the median line of the back; the metacarapace is longer in proportion to the procarapace, the distance from the cervical groove to the posterior margin of the carapace being equal to the distance from the cervical groove forwards to the front end of the post-orbital ridge, whilst in *C. advena* it falls considerably short of this; the epistoma is truncate in front, with a median spine; in *C. advena* it is more rounded in front; the antennal scale is a little wider in front, with shorter apical spine; the serrate crest on the inner border of the hand is less prominent, and the lower face of the hand is less clearly impressed at the base of this crest; the carpus is less spinulose within and below, and the line of teeth on the superior margin of the meros is obsolescent, except the two distal ones; the lateral margins of the pleuræ of the abdominal somites are straighter; the posterior segment of the telson is shorter, and the spine at the end of the median rib of the inner blade of the posterior pair of appendages is marginal, while in *C. advena* this rib terminates in a spine some distance inside the margin. The first pair of abdominal appendages are quite different, as will appear by comparison of the figures on the first plate of Hagen's Monograph, bearing in mind that the names of the two species are transposed on this plate. The distinctions noted by Hagen, based on the presence or absence of spines on the lower side of the first segment of the antennule and at the end of the cervical groove, are not good, as the former is present in Le Conte's type of *C. advena* in this Museum, and the latter is also apparent in most specimens of *C. advena*. The statement of Hagen, that "in the larger specimens the hand is more sulcated beneath at the inner margin, and the carpus more spinulose," probably refers to Le Conte's type of *C. advena* in the Philadelphia Academy.

The female specimen in the same jar with the male just noticed differs from the male in so many ways, that I doubt whether Hagen has properly referred it to the same species. Its abdomen is not only very broad, but longer than the cephalothorax, whilst in the male specimen it is considerably shorter than the cephalothorax. The carapace is not strongly compressed in the lateral direction, is more heavily punctate, the areola is not impressed, the epistoma is sharply triangular, the antennal scale broader. The tubercles of the internal border of the hand are less prominent, the external border of the hand is marginate, instead of being rounded and

obsoletely serrate, as in the male. The superior border of the meros is smooth except at the distal end. The terminal spine of the rib on the inner blade of the swimmerets is inside of the posterior margin. The annulus is quite different from that of the other species of this group, viz. *C. gracilis*, *advena*, and *simulans*, and I suspect that this female belongs to a species of the *C. Bartonii* group allied to *C. Diogenes* and *argillicola*.

All the other specimens in the Museum which are referred to *C. Carolinus* by Dr. Hagen are small specimens. No. 3368, dry female from Georgia, L. Agassiz, is certainly *C. advena*. No. 3367 (No. 1850 of Hagen), a young female also from Georgia, resembles *C. advena* in most respects, but the antennal scale is too broad near the tip. No. 230, seven young female specimens from Mobile, Ala., and No. 275, a very young male from the same locality, appear to belong to some species of the *C. Bartonii* group, rather than to the *C. advena* group, the tips of the male appendages being strongly recurved.

I am not certain of the identity of Erichson's species. Hagen examined Erichson's type (a male of the first form) in Berlin, in 1870, and thought it was *C. Bartonii*. Erichson's description, nevertheless, fits the present species very well. The shape of the carapace, the linear areola, the small abdomen, and the crest-like single row of tubercles on the inner side of the hand, certainly seem to indicate this species rather than *C. Bartonii*. Erichson's type was collected by Dr. Cabanis, who informed Dr. Hagen that all the Astacidæ he procured came from near Greenville in the upper part of South Carolina. The specimen in the Museum of Comparative Zoölogy here referred to *C. Carolinus* comes from the seaboard at Charleston. The form of the male appendages of Erichson's type would at once prove or disprove its identity with *C. Bartonii*. If it be the same, the species under consideration must receive a new name, *C. Hageniamus*. The unispinous telson of Erichson's type is probably an abnormal condition, not a specific character.

21. Cambarus gracilis.

Plate VIII. figs. 4, 4, 4″ (first abdominal appendages of male).

Cambarus gracilis, Bundy, Bull. Ill. Mus. Nat. Hist., No. 1. p. 5. 1876. — Trans. Wis. Acad. Sci., V. 182, 1882. — Geol. Wis., Surv. of 1873–79, 1. 403, 1883.
Cambarus gracilis, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. p. 18, 1876.
Cambarus gracilis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 141, 1884.

Male, form I.—Rostrum of moderate length, depressed, broad, excavated, foveolate at base; margins raised, punctate, slightly converging from the

base to near the tip, where they suddenly converge to form the short, acute, broadly triangular acumen; the acumen is slightly margined. Post-orbital ridges unarmed in front, with posterior callosities. Cephalothorax long, laterally compressed. Carapace smooth and sparsely punctate above, granular on the sides; cervical groove sinuate, no branchiostegian spine; sub-orbital angle moderately developed, rounded; areola linear, with a small anterior and a larger posterior triangular space. Abdomen shorter than the cephalothorax by the length of the rostrum, lateral margins of the pleuræ nearly straight, basal segment of the telson one- or two-spined on each side, posterior segment short, rounded; rib on inner blade of the swimmeret ends inside the margin. Basal segment of antennule with a spine beneath. Antennæ short, scale short and of moderate width. Epistoma triangular, sides convex and setose, anterior angle truncate in some specimens. Third maxillipeds furnished with long hairs within. Chela broad, inflated, punctate, squamoso-tuberculate on the inner part of the upper face of the hand; inner margin of hand serrato-dentate; fingers laterally compressed, punctate; movable finger tuberculate on the outer margin at the base; inner margins of fingers tuberculate. Carpus triangular, obliquely truncate, armed on the internal side with a long strong tooth and one or two smaller teeth and low tubercles; on the lower face there are a small external spine, a strong median anterior spine, and two or three small tubercles between the median spine and the internal tooth. Distal half of superior margin of meros tuberculate, lower face biserially spinulose. Third pair of legs hooked. Sternum hairy. First pair of abdominal appendages long, slender, twisted; internal part cylindrical, straight, apex acute, longer than internal part, bent somewhat outward; external part truncate, terminated by two horny teeth.

Length, 80 mm. Carapace, 45 mm. Width of carapace, 20 mm. Length of metacarapace, 19 mm.

Female.—Abdomen broader, annulus ventralis composed of two crescents flattened and interlocked behind, the anterior horn of each crescent making a prominent denticulated tubercle.

I have not seen the second form of the adult male. Very young males have the first pair of abdominal appendages unarmed at the tip. In the larger male specimens the movable finger is somewhat excised at the base within, and the index has a very prominent tubercle opposite the excision. In younger specimens the antennal scale is broader and more convex within than in mature specimens. Very young ones, taken from the parent, have

long, slender antennæ, and the areola is not reduced to a line in the middle, as it is in larger specimens.

C. gracilis has much the general habit of *C. Diogenes* of the same region, but the male appendages are formed after the fashion of the *C. Blandingii* group. The annulus ventralis of the female is also quite different from that of *C. Diogenes*. Apart from the sexual characters, it is distinguished from *C. Diogenes* by the very prominent single row of teeth on the inner border of the hand, the narrower cephalothorax, etc. It agrees very closely with the male specimen from Charleston, referred by me to *C. Carolinus* Erichs. (p. 54), described by Hagen on page 86, under the name of *C. advena*. The Western species differs, however, in the rostrum, which is more sharply angulated at the base of the acumen, the fore border of the carapace is angulated, the carpus and meros are more spiny, the rib on the internal lamina of the swimmeret terminates in a spine *inside the margin*. The male appendages are like those of *C. Carolinus*. It differs from *C. advena* in the male appendages and shape of rostrum. The annulus ventralis of the female is much like that of C. *advena*, but in that species the anterior tubercles are not sharply multi-denticulate, as in *C. gracilis*. The female of *C. Carolinus* has probably not yet been made known. (See p. 55.) The female specimen (M. C. Z. Cat., No. 3453) mentioned by Hagen, page 82, as an abnormal specimen of *C. obesus*, is *C. gracilis*.

According to Dr. P. R. Hoy, *C. gracilis* burrows in the clay in the prairies near Racine, Wis.; and Professor Forbes states that it is very common along water-courses, in early spring, in the neighborhood of Normal, Ill. Mr. H. Garman informs me that, among hundreds examined from such localities, he has not found a dozen males. Other localities are Lawn Ridge, Ill., Athens, Ill., and Davenport, Ia. There is a type specimen, male form I., received from Professor Bundy, in the Museum of Comparative Zoölogy.

GROUP III. (Type, C. Bartonii.)

Third segment of third pair of legs hooked. First pair of abdominal appendages of the male thick, the inner and outer parts each terminating in a short recurved tooth.

The more typical forms of this group have no lateral teeth on the rostrum, but in *C. extraneus, Jordani, Girardianus, cornutus,* and *hamulatus,* lateral rostral teeth are present. Of these five, only *C. extraneus* was known to Dr. Hagen, who placed it, on account of the rostral teeth, as an aberrant species in the *C. affinis* group. I think the structure of the male appendages is of much greater value in determining the subordinate groups of Cambarus than the form of the rostrum, which presents every condition between one with well-developed lateral teeth and one with entire margins. *C. cornutus* is peculiar in the enormous development of the antennal flagella. *C. hamulatus,* like *C. pellucidus* in Group I., is blind. It has slender chelæ, and resembles *C. pellucidus* a good deal in its general form.

- Rostrum without lateral teeth.
  - Areola broad. Rostrum long, tapering . . . . . *C. acuminatus.*
  - Areola of moderate width . . . . . *C. Bartonii, C. latimanus.*
  - Areola narrow . . . . . *C. dubius.*
  - Areola obliterated in the middle.
    - Rostrum excavated above . *C. Diogenes, C. argillicola.*
    - Rostrum plane above . . *C. Uhleri.*
    - Incertæ sedis . . . . *C. Nebrascensis.*
- Rostrum with lateral teeth.
  - Eyes well developed.
    - Antennæ of normal size. *C. Girardianus, C. Jordani, C. extraneus.*
    - Antennæ with large flagellum, ciliate on inner side. *C. cornutus.*
  - Eyes rudimentary . . . . . *C. hamulatus.*

22. Cambarus Bartonii.

? *Astacus Bartonii,* Fabricius, Suppl. Entomolog. Systemat., p. 407, 1798.

? *Astacus Bartonii,* Bosc, Histoire Naturelle des Crustacés, II. 62, Pl. XI. fig. 1, 1802. (2d ed., II. 40, Pl. XI. fig. 1, 1830.)

? *Astacus Bartonii,* Latreille, Hist. Nat. Gén. et Partic. des Crustacés et des Insectes, VI. 240, 1803. (After Fabricius.)

Astacus ciliaris, Rafinesque, Amer. Monthly Mag. and Crit. Rev., II. 42, Nov. 1817.

? *Astacus pusillus,* Rafinesque, Amer. Monthly Mag. and Crit. Rev., II. 42, Nov. 1817

Astacus Bartonii, Say, Jour. Acad. Nat. Sci. Phila., I. 167, Dec. 1817.

? *Astacus Bartonii,* Desmarest, Consid. Gén. sur la Classe des Crustacés, p. 212, 1825. (After Fabricius.)

Astacus Bartonii, Harlan, Med. and Phys. Researches, p. 230, fig. 3, 1835.

Astacus affinis, Milne Edwards, Hist. Nat. Crust., II. 332, 1837.

Astacus Bartonii, Gould, Rep. Invert. Mass., p. 330. 1841.

Astacus Bartonii, Thompson, Hist. Vermont, Part I. p. 170, 1842. (With a worthless cut.)

Astacus Bartonii, De Kay, Zoölogy of New York, Part VI., Crustacea, p. 22, Pl. VIII. fig. 25, 1844.

Cambarus Bartonii, Girard, Proc. Acad. Nat. Sci. Phila., VI. 88, 1852. (No description.)

Cambarus montanus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 88, 1852.
? *Cambarus longulus*, Girard, Proc. Acad. Nat. Sci. Phila., VI. 90, 1852.
? *Cambarus pusillus*, Girard, Proc. Acad. Nat. Sci. Phila., VI. 90, 1852.
Cambarus Bartonii, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 75, Pl. I. figs. 47–50, Pl. II. figs. 135–139, Pl. III. fig. 166, 1870.
Cambarus Bartonii, Abbott, Amer. Naturalist, VII. 80, 1873. (Habits.)
Cambarus Bartonii, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (No description.)
Cambarus Bartonii, Bundy, Trans. Wis. Acad. Sci., V. 183, 1882. — Geol. Wis., Surv. 1873–1879, I. 403, 1883. (Cited from Hagen.)
Cambarus Bartonii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 22, 1884.

Known Localities. — Dominion of Canada: St. John, N. B.; Montreal, P. Q. (?) Maine: Houlton and Maysville, Aroostook Co. (Coll. Bowdoin Coll.); Madison, Somerset Co. (Coll. Colby Univ.). Vermont: Burlington, Colchester, and Shelburne, Chittenden Co. Massachusetts: North Grafton, Worcester Co.; Williamstown, Berkshire Co. New York: Lake Champlain; Ellenburg, Clinton Co. (Coll. Peabody Acad. Sci.); Westport (Coll. Yale Coll.) and Elizabethtown, Essex Co.; Fulton Lakes, Hamilton and Herkimer Cos. (Coll. U. S. Nat. Mus.); Canton, St. Lawrence Co. (Coll. L. A. Lee); Port Jervis and Newburg (Rafinesque), Orange Co.; Fishkill, Duchess Co. (Rafinesque); Fallsburg, Sullivan Co.; Sherburne, Chenango Co. (Coll. Yale Coll.); Cazenovia, Madison Co.; Ithaca, Tompkins Co. (Coll. Yale Coll.); Berkshire, Tioga Co.; Genesee River, Rochester, Monroe Co.; Niagara, Niagara Co.; Forestville, Chautauqua Co. New Jersey: Schooley's Mountain; Orange (Coll. Yale Coll.); Trenton (Coll. Peabody Acad. Sci.). Pennsylvania: Bedford and Pattonville, Bedford Co.; Windham, Bradford Co.; Hummelstown, Dauphin Co. (Coll. Peabody Acad. Sci.); Carlisle, Cumberland Co. (Coll. U. S. Nat. Mus.); Berwick, Columbia Co. (Girard); Schuylkill River, near Philadelphia; Chester Co. (Coll. Acad. Nat. Sci. Phila.); Bainbridge, Lancaster Co. (Coll. U. S. Nat. Mus.); McKean Co. (S. I. Smith); Foxburg, Clarion Co. (Girard). Maryland: Harford Co.; Howard Co.; Montgomery Co. (Coll. P. R. Uhler); Frederick Co. (Coll. P. R. Uhler); Washington Co.; Garrett Co.; Cumberland, Alleghany Co. (Girard). District of Columbia: above Washington; Rock Creek, Georgetown. Virginia: Clarke Co. (Coll. U. S. Nat. Mus.); Alexandria Co.; Franklin, Southampton Co.; tributaries of Rappahannock River, Stafford Co.; James River (Coll. Acad. Nat. Sci. Phila.); tributaries of James River, Rockbridge Co. (Girard); Lunenburg, Lunenburg Co. (Coll. L. A. Lee); Bath Co.; Reed Creek, west of Wytheville, Wythe Co.; Holston River, Smyth Co. (Coll. U. S. Nat. Mus.). West Virginia: Williamsport, Grant Co.; South Branch of Potomac River; Glade Creek (Ran-

dolph or Tucker Co. ?); Patterson's Creek; Petroleum, Ritchie Co.; near White Sulphur Springs, Greenbrier Co.; branch of Clinch River, northern base of Clinch Mountains. North Carolina: Kinston; Newman's Fork, Blue Ridge, McDowell Co. Ohio: Marietta (Coll. Bost. Soc. Nat. Hist.); Cincinnati; Yellow Springs; Scioto River, Columbus. Indiana: New Albany; Fall Creek, Indianapolis (Coll. Peabody Acad. Sci.). Lake Superior. Kentucky: Cumberland Gap, Josh Bell Co.; Smoky Creek, Carter Co.; Kentucky River, Little Hickman, Jessamine Co.; Hickman's Landing; Bear Creek, Grayson Springs, Grayson Co.; Mammoth Cave, Edmonson Co. Tennessee: Lineville Cave, near Blountsville, Sullivan Co.; Doe River, Carter Co. (Coll. U. S. Nat. Mus.); Knoxville. Missouri: Osage River (?).

Var. **robusta.**

Cambarus robustus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 90, 1852.
Cambarus robustus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 80, Pl. III. fig. 167, 1870.
Cambarus robustus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (Cited from Hagen. No description.)
Cambarus robustus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 143, 1884

Known Localities. — Dominion of Canada: Humber River (Coll. Acad. Nat. Sci. Phila.) and Don River, Toronto, and Indian Creek, Weston, Province of Ontario. New York: Forestville, Chautauqua Co.; Genesee River, Rochester, Monroe Co.; Sodus, Wayne Co.; tributaries of Racket River, near Tupper's Lake, St. Lawrence Co. (Coll. L. A. Lee); Canton, St. Lawrence Co. (Coll. L. A. Lee); Fulton Lakes, Hamilton and Herkimer Cos. (Coll. U. S. Nat. Mus.); Natural Bridge, Jefferson Co. (Coll. C. H. Merriam). Maryland: Montgomery Co. (Coll. P. R. Uhler). Virginia: Fredericksburg, Spottsylvania Co. Illinois: Decatur, Macon Co. (Coll. Bost. Soc. Nat. Hist.). Tennessee ? (Coll. Bost. Soc. Nat. Hist.).

In the Museum of Comparative Zoölogy there is a specimen of *C. Bartonii* (Cat. No. 3358) labelled "Charleston, S. C.?" and three specimens (No. 1101) in the same jar with an Alpheus are marked "Pico, Azores, Miss O. Dabney, May 23, 1860." The latter locality, at any rate, is probably erroneous. Hagen states (p. 77) that he has seen a specimen from Georgia; and I find in the collection of the Boston Society of Natural History this species in the same bottle with a Pagurus and *Hyas coarctatus*, labelled "Savannah, Ga., Dr. H. Bryant." The presence of the marine forms, especially the Northern Hyas, casts doubt on the correctness of the label. The locality label, "Osage River," is marked by Dr. Hagen as being very doubtful.

The centre of distribution of this common Eastern species seems to be the Appalachian Mountain system in Pennsylvania, and the Susquehanna and Delaware Rivers with their tributary streams. To the northward from this region it is found throughout the State of New York, in the basins of the Susquehanna, Delaware, Hudson, and St. Lawrence Rivers. I have seen Massachusetts specimens from Williamstown, Berkshire Co. (Hudson River basin), and from Grafton, Worcester Co. (Blackstone River basin). The Grafton specimens were lately collected by Mr. L. W. Sargent, in a clear, cold spring. I have been unable to obtain any specimens from Rhode Island or Connecticut, but Prof. E. P. Larkin informs me that about forty years ago crayfishes (*C. Bartonii*?) were not uncommon at Westerly, R. I., on the Pawcatuck River near the border of Connecticut. Vermont specimens have been received from Chittenden Co. on Lake Champlain. According to Zadock Thompson, *C. Bartonii* is very common in many of the small streams in the western part of the State. In the State of Maine, it occurs in the valleys of the St. John, Kennebec, and Penobscot.* I have myself seen specimens from Houlton and Maysville, Aroostook Co. (St. John valley), and from Madison, Somerset Co. (Kennebec valley). Other localities in the State from which crayfishes (probably *C. Bartonii*) have been reported are the following: Heron Lake (Thoreau†) and Churchill Lake (A. S. Packard) on Allegash River, a tributary of the St. John; Moosehead Lake and Solon in the Kennebec valley (*fide* Wm. Elder); Lobster Pond (see Thoreau, Maine Woods, p. 99) and Patten in the Penobscot valley. Professors Verrill and Smith, who have explored the neighborhood of Norway, Oxford Co., in the Androscoggin valley, are confident that no Cambari are found in that part of the State. The easternmost point from which *C. Bartonii* has been received is St. John, New Brunswick.

To the westward, *C. Bartonii* extends into the valley of the Ohio River and its tributaries, in the States of Pennsylvania, West Virginia, Virginia, Ohio, Indiana, Kentucky, and Tennessee.

Southerly its range involves the area drained by the rivers that debouch into Chesapeake Bay, in Maryland and Virginia. From North Carolina I have seen specimens collected in the mountain region of the western part of the State (McDowell Co.), and at Kinston in the eastern part of the State

* The St. John and Penobscot are connected by a canal from Telos Lake to Webster Pond, and the divide between the head-waters of the Penobscot and the Kennebec is so low that it is said that in very wet seasons their waters mingle. (See Thoreau, Maine Woods, pp. 36, 250.)

† Maine Woods, p. 237.

(Neuse River basin). It is doubtfully reported from South Carolina and Georgia; but its place seems to be largely taken in those States by the nearly related *C. latimanus*. Lake Superior and Osage River are isolated Western localities from which *C. Bartonii* is reported.

As a rule, *C. Bartonii* prefers the cooler waters of mountain regions or uplands, while the clay bottoms and marshes, both on the east coast and in the Western prairie country, afford the related *C. Diogenes*. According to Dr. C. C. Abbott, *C. Bartonii* in the neighborhood of Trenton, N. J., burrows in the muddy banks of ditches, small streams, and of the Delaware River. He says: "The burrows of *Cambarus Bartonii*, so far as we have discovered them, have all been in the banks of the smaller streams and meadow ditches (and occasionally a colony of burrows in the river bank, where peculiarly favorable), a little below the usual water line." It is not, however, pre-eminently a burrowing species, like its cousin, *C. Diogenes*, being more commonly found under the stones in clear streams and in springs. In the U. S. National Museum are young specimens found in a spring in Clarke Co., Va., the temperature of whose water is 67° F. The observations of Dr. Godman* upon the habits of a burrow-dwelling species probably relate to *C. Bartonii*.

According to Dr. John Sloan, of New Albany, Ind., *C. Bartonii* is found in ponds and still water in that locality, *C. Sloanii* being the common form in the running streams.

The well-known occurrence of *C. Bartonii* with well-developed eyes in the Mammoth Cave of Kentucky is mentioned on p. 41. Mr. A. R. Crandall has also collected it in Lineville Cave, near Blountsville, Tenn.

As might be expected in a species with such an extended geographical range, *C. Bartonii* is subject to considerable variation. The variations affect especially the rostrum, areola, antennal scale, epistoma, and chelæ. In the common Eastern form, the rostrum is short, broad, nearly plane above, the sides nearly parallel from the base to near the tip, where they suddenly converge to form the short acumen. The antennal scale is narrow. The areola is rather narrow, with two or three longitudinal rows of impressed dots. The chelæ are coarsely punctate, the internal margin of the hand subtuberculate, the fingers gaping at base. To the westward, in the Alleghany Mountain region of Virginia, and in the Ohio River basin, specimens are found in which the rostrum is longer and narrower, the margins converging

* Rambles of a Naturalist, with a Memoir of the Author, Dr. John D. Godman, p. 42. Philadelphia, 1859. (Republished from "The Friend.")

more gradually to form the longer acumen. The areola is wider and more punctated, the antennal scale broader at the tip. This is the form described by Girard under the name of *C. montanus*. From this form we easily pass to one with a still more elongated rostrum, hand and fingers scarcely tuberculated, external finger bearded within at the base, antennal scale truncate at the end, with the inner margin straight and parallel to the outer one. The epistoma is short and transverse. This form I have called *C. Bartonii*, var. *longirostris*. It is perhaps the same as Girard's *Cambarus longulus* (see p. 66). My specimens come from Eastern Tennessee and West Virginia. Three from Cumberland Gap have a well-marked lateral spine on the carapace. There are so many varieties connecting this one with the more typical forms with a short rostrum, that I cannot regard it as a distinct species.

Even among those with the short quadrangular rostrum there is considerable variation, the upper surface of the rostrum being more or less hollowed out and the margins thickened, and the areola of variable width. From one locality, Cincinnati, Ohio, come three forms which are readily distinguishable from each other. In one of these (M. C. Z., No. 267) the rostrum is subquadrangular, the antennal scale narrow, and the areola narrow (2 mm. in a specimen 75 mm. long) with two longitudinal lines of dots. This comes very near the common Eastern form, but the rostrum is more excavated above. In another form (M. C. Z., No. 288) the rostrum is also quadrangular, but the areola is broad (4 mm. in a specimen 91 mm. long) and thickly sown with dots. The cervical groove is more sinuate, the post-orbital ridge shorter. The third form (M. C. Z., No. 243) has a somewhat longer and more tapering rostrum, an almost linear areola, antennal scale broad near the tip, and a shorter and more conical hand. This form approaches *C. latimanus*, and may be a distinct species from *C. Bartonii*.

In specimens from the Mammoth Cave, the antennæ are extremely long ($1\frac{1}{3}$ times as long as the body), the antennal scale broad and sub-truncate at the end; the metacarapace is very long, and a lateral spine is evident. The margins of the rostrum are angulated at the base of the acumen, in young specimens even toothed. The terminal segment of the telson is oval. The largest specimen from the cave, a male of the first form, measures 108 mm. from tip of rostrum to posterior border of telson.

Fabricius's description of *Astacus Bartonii* is as follows: —

"A. thorace lævi. rostro brevi, acuminato, carpis dentatis.

"Habitat in America boreali. Prof. Smith Barton.

"A. fluviatili minor. Thorax lævis, punctatus, lateribus antice parum scabris. Rostrum breve, planum, apice acuminatum. Chelæ sex, anticis majoribus, brachiis serratis, carpis dentatis, manibus ovatis, lævibus, punctatis, reliquiis quatuor filiformibus."

As Dr. Barton lived in Philadelphia, the specimen sent by him to Fabricius was probably the species now commonly known as *C. Bartonii*.

Bosc's type probably came from South Carolina, as Desmarest asserts, and may have been some other species. His figure is too defective for identification.

Rafinesque's *A. ciliaris*, from Fishkill, Newburg, etc., N. Y., is without doubt this species, and his description of *A. pusillus* is probably based on small specimens of the same species. It runs thus: "Antens length of the thorax, rostrum oval acute, a thorn and a longitudinal angle behind each eye; three pairs of pinciferous feet, hands of the first oblong dotted, wrist smooth. Obs. A very small species, living in the brooks near Saratoga, Lake George, Lake Champlain, Utica, Oswego, etc. Length one or two inches; vulgar name, brook prawn, shrimp, or lobster; entirely fulvous brown."

Say's description was evidently drawn up from this species, although his supplemental remarks on page 443, where he says it is extremely common in the pine-barren marshes of the Southern States, particularly Georgia and Florida, probably relate to some other species.

Milne Edwards, misled by the transposition of the numbers of Harlan's figures, has described *C. affinis* under the name of *A. Bartonii*; *C. Bartonii* (or a closely related species), under the name of *A. affinis*.

The Museum of Comparative Zoölogy contains specimens of *C. latimanus* from South Carolina, labelled *A. Bartonii* by Dr. Lewis R. Gibbes, and in the collections of the Academy of Natural Sciences of Philadelphia are specimens of *C. rusticus*, var. *placida*, also labelled *A. Bartonii* by the same writer. The localities given by Gibbes for *A. Bartonii*, therefore, cannot be taken as belonging to this species.

Erichson's types of *C. Bartonii* in the Berlin Museum were examined by Dr. Hagen in 1870. They are a male, form II., and a young female, and according to Dr. Hagen both are *C. latimanus*. They were collected by Cabanis in upper South Carolina. Erichson's type of *C. Carolinus*, also from South Carolina, appeared to Dr. Hagen to be *C. Bartonii*, but the description of Erichson agrees much better with the species formerly referred to *C. Carolinus* by Hagen.

Girard does not describe his *C. Bartonii*, but cites as synonymous *A. Bartonii* of Fabricius, Latreille, Bosc, Say, Harlan, and Gould, and *A. ciliaris* of Rafinesque. His localities are Foxburg, Carlisle, and Berwick, Pa. Hagen examined a specimen from the latter locality, communicated by Stimpson, undoubtedly one of Girard's types. This specimen agreed perfectly with Hagen's *C. Bartonii* from the Schuylkill River. There is now in the collection of the Academy of Natural Sciences of Philadelphia a dry female specimen labelled "*C. Bartonii*? Cohaxie [Coxsackie?]," in the same handwriting as the other species of Girard mentioned on page 11. It is the typical Eastern form of *C. Bartonii*, with two longitudinal rows of dots in the areola, narrow antennal scale, and short, quadrangular rostrum.

Girard also describes *C. montanus*, sp. nov., *C. longulus*, sp. nov., *C pusillus*, sp. nov., and *C. robustus* (Raf.). The types of *C. montanus* came from the Alleghany regions in Maryland, Virginia, and West Virginia. A young second-form male type from Greenbrier River, W. Va., was compared by Hagen, and deemed identical with *C. Bartonii*. The young male in the Philadelphia Academy, labelled "*C. montanus*? James River, Va.," said by Hagen to be identical with the type of *C. montanus*, has been examined by me. The rostrum is more oval than in the common form of *C. Bartonii*, the antennal scale broader near the tip, the areola more punctate, with the dots irregularly disposed over the whole field of the areola. It cannot be separated specifically from *C. Bartonii*.

The type of *C. longulus*, from the Middle States, was also examined by Dr. Hagen, and thought to be a deformed specimen of *C. Bartonii*. "The fingers are cylindrical, very widely separated at the base, and bearded in this place and inside of the external finger, along the basal half. . . . . The other differences quoted by Mr. Girard, and taken from the shape of the rostrum and the breadth of the areola, are not important enough to warrant a specific separation." According to Girard's description the areola is very broad, the rostrum much narrower and longer than in *C. Bartonii* and slightly concave on the sides. The specimens described above under the name of *C. Bartonii*, var. *longirostris*, perhaps are the same form as *C. longulus*. They agree with Girard's description in the length of the rostrum, and the external finger is bearded within in accordance with Hagen's description of Girard's type.

Girard's type of *C. pusillus* came from the stomach of a *Lota maculosa* taken in Lake Ontario three miles from shore, off Oswego, N. Y. Compared with

C. montanus, the antennæ were longer, the rostrum was more tapering and terminated in a more elongated point, and the areola narrower. This was probably a form of *C. Bartonii*, whether identical with Rafinesque's *C. pusillus* or no is doubtful.

C. robustus Girard, not an uncommon form in the St. Lawrence valley about Lake Ontario, is so near to *C. Bartonii* that it is best treated as a variety of that species. The differences are sufficiently pointed out by Hagen on page 80 of the Monograph of the North American Astacidæ. They are hardly greater than in some of the varieties of *C. Bartonii* noticed above. Both forms, *C. robustus* and the typical *C. Bartonii*, are found together in some parts of New York State. A male specimen in the collection of the Academy of Natural Sciences of Philadelphia, from Humber River, Toronto, is probably one of Girard's types. There is a male specimen from Decatur, Ill., in the collection of the Boston Society of Natural History, and two small specimens from Tennessee, Dr. Curtis, which appear to be *C. robustus*. In the Philadelphia Academy there is also a young specimen from Florida that resembles *C. robustus*, but the antennal scale is broader at the tip. *C. Bartonii*, var. *robusta*, is also found in Virginia. I have seen specimens 86 millimeters in length.

The first abdominal appendage of the male *C. Bartonii*, var. *robusta*, is figured by Brocchi, Ann. Sci. Nat., 6e Sér., Zool. et Palèontol., II., Pl. XIII. fig. 15.

In the Report on the Crustacea of the United States Exploring Expedition (Pt. I. p. 525, Pl. XXXIII. fig. 2) Dana describes and figures as *Astacus* (*Cambarus*) *Bartonii* a crayfish of uncertain locality, "possibly from Brazil." It is clearly not *Cambarus Bartonii*, neither is it the same as the Brazilian Parastacine crayfish in the Museum of the Academy of Natural Sciences of Philadelphia, as Hagen suggests (p. 11). I have not been able to find Dana's type in the collections of the Smithsonian Institution.

23. Cambarus acuminatus.

Plate III. fig. 5, Plate VIII. figs. 6 a, 6 a'.

Cambarus acuminatus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 113, 1884.

Rostrum long, tapering, ending in a long, sharp acumen, without lateral spines; upper surface smooth, somewhat hollowed out, margins punctate, ciliate, raised into low sharp crests. Post-orbital ridges with sharp anterior

spines. Carapace smooth, punctate, granulated on the sides, cervical groove sulcate, sinuate; a sharp lateral and branchiostegian spine; suborbital angle rounded; an irregular indentation on the side of the carapace, below the lateral spine, on the hepatic region and anterior part of the branchial region; areola broad, smooth, punctate, less than half as long as the distance from the tip of the rostrum to the cervical groove. Telson bispinose on each side. Epistoma triangular, angles rounded. Second and third segments of the antennæ with a strong sharp spine; scale of moderate length, rather broad, inner margin rounded, outer margin thick, turned outwards at the tip. Third maxillipeds hairy within. Chela moderate, punctate, serrato-tuberculate on internal border, fingers setose on their inner margins, external border of outer finger submarginate. Carpus armed with a strong internal spine and smaller inferior median and external spines. Meros with well-developed biserial spines below, and two obliquely placed near the distal end of the superior border. In some specimens one of the superior pair is obsolete. Third pair of legs hooked. First pair of abdominal appendages as in *C. Bartonii*.

Length, 48 mm. Carapace, 23 mm. Rostrum, 6 mm. Areola, 7 mm. Breadth of areola, 2 mm.

Saluda River, west of Greenville, S. C. Collected by Prof. D. S. Jordan. Three specimens, one male of the second form, two females. For the opportunity to examine these I am indebted to Prof. O. P. Hay of Butler University, Irvington, Ind. Differs from the other species of the *C. Bartonii* group in its long, gradually tapering rostrum, short metacarapace, strongly developed spines of carapace, antennæ, and meros. The acumen of the rostrum is scarcely upturned at the tip.

Specimens from North Carolina, Old Fort, McDowell Co., and French Broad River (in Mus. Comp. Zoöl. and Acad. Nat. Sci. Phila.), differ from the above in having the rostrum flatter and less attenuated at the tip, a shorter antennal scale, sub-orbital angle produced into a sharp spine. These may prove to be a distinct species from the Saluda River specimens. They approach *C. Bartonii*, var. *robusta*, but may be distinguished from that form by the longer-pointed rostrum, shorter metacarapace, better-developed spines, etc.

24. Cambarus latimanus.

Plate II. fig. 3.

? *Astacus* (*Cambarus*) *Bartonii*, Erichson, Arch. Naturgesch., XII. Jahrg., I. 97, 1846.
Astacus latimanus, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 402, 1855.
Cambarus latimanus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 83, Pl. I. figs. 43–46, Pl. III. fig. 162, 1870.
Cambarus latimanus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 144, 1884.

Known Localities.—South Carolina: near Columbia (Coll. U. S. Nat. Mus.); near Greenville (Coll. Berlin Mus., *teste* Hagen). Georgia: Athens; Milledgeville; Roswell. Alabama: Blount Spring and Cullman, Sand Mountain; near Bridgeport (var.). Mississippi: Ocean Springs. Tennessee: near Ashland City, Cheatham Co. (var.).

Erichson's types of *C. Bartonii* in the Berlin Museum were examined by Dr. Hagen in September, 1870. They consist of a male of the second form and a young female collected by Cabanis in the upper part of South Carolina, near Greenville. Hagen considered them both to be young *C. latimanus*. A large *C. Diogenes*, from St. Louis, Mo., with a deformed rostrum, in the same museum, was also labelled *Astacus Bartonii* by Erichson.

There is a type, male form I., of Le Conte's *A. latimanus* in the Museum of Comparative Zoölogy, and another, a female, in the Philadelphia Academy. Two specimens from South Carolina in the Museum of Comparative Zoölogy were received from Dr. Lewis R. Gibbes as "*Astacus Bartonii* Fab."

One male specimen, in the same jar with *C. latimanus*, from Athens, Ga., has a rather broad areola, and seems to be a form of *C. Bartonii*, rather than of *C. latimanus*.

Mr. C. L. Herrick collected small specimens at Ocean Springs, Miss., on the Gulf of Mexico, which appear to be this species, but its favorite habitats are the higher regions at a distance from the coast.

In specimens from Blount Spring and Cullman, Ala., the areola is somewhat narrower than in the types from Georgia; and in those received through the U. S. National Museum from Bridgeport, Jackson Co., Ala., and Ashland City, Cheatham Co., Tenn., the areola is almost reduced to a line in the middle, the metacarapace is longer in proportion to the procarapace, the fingers are shorter, the tuberculation of the hand weaker, the epistoma narrower and less sharply truncate. In the typical specimens from Georgia the distance from the cervical groove to the hind margin of the carapace is equal to the distance from the cervical groove forwards to the middle of

the post-orbital ridges. In the form from Bridgeport and Ashland City it is equal to the distance from the cervical groove forward to the anterior spines of the post-orbital ridge.

25. Cambarus dubius.

Plate IV. fig. 3, Plate VIII. figs. 7, 7.

Cambarus dubius, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 114, 1884.

Rostrum short, broad, sides subparallel from the base to near the tip, when they suddenly converge to form the short, broadly triangular acumen; the rostrum is angulated, but not toothed, at the base of the acumen; upper surface of rostrum concave, sides thickened, punctate-lined. Post-orbital ridges without spines, slightly swollen at the posterior end. Carapace longer than the abdomen, oval, punctate, granulated on sides, posterior dorsal margin depressed, cervical groove hardly sinuate, crossing the median line of the back half-way between the base of the rostrum and the posterior margin of the carapace; lateral and branchiostegian spines obsolete; sub-orbital angle little developed, obtuse; areola narrow, with two irregular longitudinal rows of dots. Epistoma subquadrangular. Abdomen small, short; anterior segment of telson bispinose on each side, posterior segment rounded behind. Antennæ shorter than the body, second and third segments without spines, scale small. External maxillipeds hairy within. Chela punctate, inner margin of hand serrato-tuberculate, outer margin thickened, serrate; fingers somewhat down-curved, slightly gaping, toothed on their opposed margins. Carpus with a strong tooth on the inner side, teeth of the lower side obsolescent. Superior border of meros serrate, lower side armed with two rows of spines. Third pair of legs hooked. First pair of abdominal legs of the first form of the male short, thick, twisted; internal part cylindrical, recurved, with pointed apex; external part broader, plane within, apex recurved, compressed, external margin corneous, striated.

Length, 62 mm. Carapace, 33.5 mm. Abdomen, 28.5 mm. Rostrum, 5 mm. Metacarapace, 15 mm. Width of areola, 1.5 mm.

Known Localities. — West Virginia: Cranberry Summit, Preston Co. Virginia: Pennington's Gap, Lee Co. Tennessee: Cumberland Gap.

This species has the general appearance of *C. Diogenes*, but the rostrum is short, as in *C. Bartonii*, and the areola is not obliterated in the middle

by the apposition of the branchio-cardiac lines. The few (four) specimens which I have seen come from the Appalachian Mountain region of Virginia and West Virginia. According to Mr. Uhler, it makes mud chimneys like *C. Diogenes*, which it seems to represent in the mountain regions, *C. Diogenes* belonging to the lowlands.

26. Cambarus Diogenes.

Cambarus Diogenes, Girard, Proc. Acad. Nat. Sci Phila., VI. 88, 1852.
Cambarus obesus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 81, Pl. 1. figs. 39–42, Pl. III. fig. 163, Pl. IX., 1870.
Cambarus obesus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (After Hagen. No description.)
Cambarus obesus, Forbes, Bull. Ill. Mus. Nat. Hist., No. 1. pp. 5, 19, 1876.
Cambarus obesus, Bundy, Proc. Acad. Nat. Sci. Phila., 1877, p. 171. — Trans. Wis. Acad. Sci., V. 183, 1882. — Geol. Wis., Surv. 1873–1879, I. 403, 1883. (No description.)
Cambarus Diogenes, Faxon, Proc. Amer. Acad. Arts and Sci., XX. p. 144, 1884.
Cambarus Diogenes, var. *Ludoviciana*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. p. 144, 1884.

Known Localities. — New Jersey: Mercer Co. Pennsylvania: Derry Station, Westmoreland Co. Maryland: Baltimore Co.; St. Mary Co.; Caroline Co. (Coll. P. R. Uhler); Dorchester Co. (Coll. P. R. Uhler); Worcester Co.; Deer Park, Garrett Co. (Coll. P. R. Uhler). District of Columbia: near Washington. Virginia: Alexandria Co.; Accomack Co.; Northampton Co.; Fredericksburg; Petersburg. North Carolina: Wilmington (Coll. U. S. Nat. Mus.); Kinston (Coll. U. S. Nat. Mus.). Ohio: Kelley's Island, Lake Erie (Peabody Acad. Sci.). Indiana: Long Lake, Kendallville, Noble Co. (Bundy); Mechanicsburg, Henry Co. (Bundy); Knox Co. (Coll. U. S. Nat. Mus.). Illinois: Lawn Ridge; Evanston; Belleville; Decatur; Chicago; Abingdon (Coll. L. A. Lee and B. F. Koons). Michigan: Detroit. Wisconsin: tributaries of Pecatonica River, Green Co.; Appleton (Coll. Butler Univ.); Racine (Coll. Acad. Nat. Sci. Phila.). Iowa: Davenport. Missouri: Carroll Co. (Coll. Bost. Soc. Nat. Hist.); St. Louis (Coll. Berlin Mus., *teste* Hagen). Kansas: Leavenworth. Colorado: Clear Lake. Wyoming: Cheyenne. Arkansas. Kentucky: near Louisville? Mill Branch, near Bee Spring, Edmonson Co.? Mississippi: Monticello, Lawrence Co. Louisiana: New Orleans.

The labels of specimens, probably types, of *C. Diogenes* and *C. propinquus*, in the Philadelphia Academy have been transposed accidentally, so that Dr. Hagen failed to see the identity of the former and his own *C. obesus*. Girard's diagnosis is too incomplete to be of much value, although his account of

the peculiar mode of life of this species would serve to identify it to those familiar with its habits.

Specimens from the West are larger than the Eastern examples, and have a broader antennal scale. In many of the Eastern specimens, moreover, the bounding lines of the areola are not so closely approximated as in the Western form, a very narrow linear space being left in the centre. Specimens from New Orleans, La., have a narrower rostrum with the sides nearly parallel, a narrower epistoma, and metacarapace longer in proportion to the procarapace. This form I have called *C. Diogenes*, var. *Ludovicianus*.

A male specimen (M. C. Z., No. 3609) from Detroit, Mich., collected by Mr. H. G. Hubbard from a burrow in blue clay in company with *C. argillicola*, differs from the common Western form in having a narrower, more tapering rostrum, less clearly foveolate at its base, a longer apical spine to the antennal scale, and the post-orbital ridge more interrupted anteriorly to the posterior callosity, which is in the form of a prominent tubercle. The fingers are shorter, giving the chela a more conical shape. The terminal segment of the telson is more oval behind, and the sides of the areola are not so closely approximated. A female specimen (M. C. Z., No. 3458) from the neighborhood of Mammoth Cave agrees very nearly with this male from Detroit. The body is more attenuated than in the ordinary form, in this resembling *C. gracilis*. The other specimens which I have seen from Kentucky are too small to determine with certainty.

I have seen no specimens of *C. Diogenes* from Tennessee, although it probably inhabits that State, judging from the mud "chimneys," similar to those built by this species, collected by Mr. Edward Palmer.

The female noticed by Hagen (p. 82), considered by him to be an abnormal and deformed specimen of *C. Diogenes*, is *C. gracilis* Bundy.

C. Diogenes is pre-eminently a burrowing species, being found in meadows and clay bottoms, often at a great distance from any permanent stream. Girard has given an account of their burrows and the mud "chimneys" which they build over them. His observations were made in the neighborhood of the city of Washington. "The holes, as they appear at the surface of the ground, are nearly circular, from seven tenths of an inch to one inch and one inch and a half in diameter. The depth of the burrows varies according to the locations; this we generally found to be from sixteen inches to two feet, and sometimes to three feet and more. The construction of the burrow itself is often exceedingly simple: from the surface

of the ground the excavation exhibits a gradual slope, in direction more or less undulating for a distance from five to ten inches, when it becomes vertical for six or eight inches, and then terminates in a sudden bottle-shaped enlargement, in which the animal is found. The bottom of the burrow having no subterraneous communication, no other issue except towards the surface, it is entirely isolated from its neighbors, and leaves no chance for escape to its inhabitant. The same burrow may have several external holes connected with it, several inclined channels, which, however, meet at the depth where it becomes vertical. We found constantly the cavity full of water, but this was in March and April. The bottom, for several inches, was filled with soft and pulpy mud.

"There are other instances of burrows somewhat more complex. Their direction may be oblique throughout their whole extent, and composed of a series of chambers or ovoid enlargements succeeding each other at short intervals. Sometimes, also, and connected with one of the chambers, a narrow and nearly vertical tubuliform channel extends downwards to a much greater depth, and appears to us as a retreat either during the cold winters or else during the dryness of the summer, when water is low. That it is not for the mere purpose of escaping pursuit, we infer from the fact that we repeatedly caught the animals in the chambers above, where they remained quietly, instead of attempting to disappear into the apartments below. . . . .

"In the spring, and we are told in the fall also, the burrowing crawfish builds over the holes of its burrow a chimney of the maximum height of one foot, but most generally lower. The chimney, circularly pyramidal in shape, is constructed of lumps of mud, varying in size, irregularly rolled up, and piled up one upon each other, and intimately cemented together. Its exterior has a rough and irregular appearance; whilst the interior is smooth and as uniform as the subterraneous channel, having the same diameter as the latter. . . . .

"The animal works during night. How the work is performed has not yet been ascertained by actual observations. . . . . On an examination of these chimneys, we detected the imprints of the second and third pair of claws, which indicate, evidently, that the parcels of mud, once brought to the surface, ... are arranged and fixed in their definitive place by means of these organs.

"When the work has thus been carried on towards completion, the last

touch consists in shutting up the aperture. This is accomplished by means of several balls of mud, brought up from underneath, deposited temporarily on the edge of the chimney, and drawn back in close contiguity, so as to intercept all communication with the external world."*

Another account of the burrows and mounds of *C. Diogenes*, by R. S. Tarr, has recently been printed, with diagrams, in "Nature," Vol. XXX. p. 127, June 5, 1884.† Mr. Tarr's observations, like Girard's, were made in the neighborhood of Washington. According to Mr. Tarr, the eggs hatch about the middle of May, while the parent is living within her burrow; but Mr. P. R. Uhler tells me that during the period of incubation the female goes into pools, ditches, and quiet waters along the margin of overflowing creeks. Mr. Tarr believes that the chimneys result from the excavation of the burrow, without implying design on the part of the crayfish. Dr. C. C. Abbott,‡ on the contrary, is convinced that they are carefully designed, since they are often built on the steeply sloping banks of ditches, where the ejected balls of mud would surely roll into the ditch if they were regarded by the crayfish simply as rejected matter. In fact, an artistic tower, only two inches in diameter and varying from eight to eleven inches in height, is erected on the steep incline. In several such instances observed by Dr. Abbott the base of the tower was provided for by levelling the ground before the foundation pellets of mud were laid. Of a series of forty towers observed by Dr. Abbott on the banks of a ditch, not one, in his estimation, could have been the result of accident.

As these pages are going through the press, I have received an article by Dr. Abbott,§ which states that his nephew, Mr. Jos. DeB. Abbott, has seen the crayfish engaged in building its chimney. The observation was made in the night by the light of a candle. The crayfish was seen to emerge partially from its burrow, bearing "on the back of its right claw a ball of clay mud which, by a dexterous tilt of the claw, was placed on the rim of the chimney. Then the crayfish remained perfectly quiet for a few seconds, when it suddenly doubled up and dropped to the bottom of its burrow.

* Girard states that Mr. T. R. Peale informed him that he had observed mud chimneys, similar to those built by *C. Diogenes*, in New Grenada, along the Rio Magdalena, several hundred miles from the sea. This observation is of interest, as indicating the possible southward extension of Cambarus beyond the Isthmus of Panama.

† "Habits of Burrowing Crayfishes in the United States."

‡ "Are the 'Chimneys' of Burrowing Crayfish designed?" Amer. Naturalist, Vol. XVIII. p. 1157, November, 1884.

§ "How the Burrowing Crayfish works." The Inland Monthly, Vol. I pp. 31, 32, Columbus, Ohio, February, 1885.

There elapsed some three or four minutes between each appearance; but every time it came, it brought a ball of clay and deposited it in the manner I have described. About two fifths of the balls were not placed with sufficient care, and rolled down the outside of the chimney."

Dr. Abbott believes that the closing of the orifice of a chimney is merely the result of the accidental falling in of pellets from the rim, loosened perhaps by atmospheric moisture. In some localities where the burrowing crayfish abounds, there is a weather proverb to the effect that, when the crayfish closes the opening of his chimney in dry weather, there will be a rainfall within twenty-four hours.

It is difficult to imagine the object of this crayfish in building these elaborate subterranean abodes. Further observations on the method of tunnelling, on the winter habits of the animal, and on its mode of life during the breeding season, are much needed.

The mud chimneys built by *C. Diogenes* were observed and figured long ago by Audubon (Birds of America, Plates 222, 386; 8vo ed., Plates 360, 370), who describes the ingenious device whereby the White Ibis draws the crayfish from its retreat (Vol. VI. p. 57).

In life *C. Diogenes* is olive-colored, reddish on the margins of the rostrum, the post-orbital ridges, and the margins of the abdominal somites; chelæ cream-colored within, fingers reddish.

The largest specimen which I have seen from the East measures 84 mm. from the tip of the rostrum to the end of the telson. Specimens received from Illinois measure 111 mm. in length.

According to Forbes and Bundy, *C. Diogenes* is one of the commonest species in Illinois and Wisconsin.

27. Cambarus Nebrascensis.

Cambarus Nebrascensis, Girard, Proc. Acad. Nat. Sci. Phila., VI. 91, 1852.
Cambarus Nebrascensis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 83, 1870. (After Girard.)
Cambarus Nebrascensis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 145, 1884. (After Girard. No description.)

"Rostrum intermediate in form between that of *C. robustus* and *C. Diogenes*. Dorsal lines of suture of the carapace in close contiguity. Large claw nearly conical, giving to the species a very peculiar aspect.

"*Locality.*—Fort Pierre (Nebraska); collected in 1850 by Thaddeus Culbertson." Girard.

This species is unknown to me. Girard places it in his second group of species (*C. Bartonii* and allies), with toothless rostrum and male appendages recurved at their extremity. I am inclined to think that it is a Western form of *C. Diogenes*, or possibly *C. argillicola*. Fort Pierre is on the right bank of the Missouri River, at the mouth of Bad River, within the present limits of the Territory of Dakota. Specimens of *C. Diogenes* collected at Cheyenne, Wyoming, have the hand broad and fingers rather short, so that the chela assumes a triangular shape when the fingers are closed. They do not differ from *C. Diogenes* enough to warrant a separation, but are very likely the form named *C. Nebrascensis* by Girard. I do not know what Hagen means when he says the hands resemble in shape those of *C. Mexicanus*.

28. Cambarus argillicola.

Plate IV. fig. 2.

Cambarus argillicola, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 115, 1884.

Rostrum short, broad, down-curved, excavated, with a deep foveola at base; acumen short, broadly triangular, acute, no lateral spines. Post-orbital ridges without anterior spines, swollen behind. Cephalothorax laterally compressed, carapace punctate, anterior border not angulated, cervical groove sinuate, no lateral or branchiostegian spine. Areola linear in the middle, with an anterior and posterior triangular space, the latter the larger. Abdomen broad, but narrow at the base, longer than the cephalothorax. Telson uni- or bi-spinose on each side. Epistoma rounded in front. Antennal scale small, rounded within. Third maxillipeds heavily bearded within, lightly so beneath. Chela large, hand swollen, denticulate on inner border, irregularly punctate, fingers flattened laterally, punctate and costate; the movable finger has a single row of tubercles on its external border and a very prominent rib on its upper face; its internal, cutting edge is toothed and excised at the base; the outer finger is sharply marginate on its external border, inner border toothed and heavily bearded at the base. Carpus armed with a sharp spine and a few minute tubercles within; beneath them is a sharp median anterior spine, and a minute spiniform tubercle between this and the spine of the internal border. Meros furnished with one or two small subapical teeth on the superior border, and two rows of teeth below. Second pair of legs ciliate near the end. Third pair of legs

of male hooked. First abdominal appendages of male and annulus of female as in *C. Diogenes*.

Length, 76 mm.

Known Localities. — Dominion of Canada: Toronto, Prov. Ontario. Michigan: Detroit, East Saginaw (Coll. Peabody Mus. Yale Coll.). Indiana: New Albany. Louisiana: New Orleans (Coll. U. S. Nat. Mus.). North Carolina: Kinston.

Closely related to *C. Diogenes*, but at once distinguished by the sharply compressed fingers bearded at the base, excised thumb with a single row of tubercles on external margin, non-angulated anterior border of carapace, etc. The types of this species were dug out of burrows in solid blue clay in Detroit, Mich., by Mr. H. G. Hubbard, in August, 1873. The burrows were three to five feet deep. At the bottom of each burrow was a pocket in a layer of loose gravel and clay, holding water. Just above the water line an enlargement in the burrow formed a shelf on which the animal rested.

Specimens from Kinston, N. C., and New Orleans, La., which I have referred to this species, are not adult, and cannot be determined with absolute certainty.

29. Cambarus Uhleri.

Plate VIII. figs. 8, 8′, 8 a, 8 a′ (first abdominal appendages of male *).

Cambarus Uhleri, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 116, 1884.

Male, form I.—Rostrum of moderate length, sides nearly parallel to base of acumen, which is broadly triangular, acute; no lateral spines; upper surface of rostrum plane, punctate, lightly foveolate at base, margins raised into a low, sharp crest, punctate-lineate; there is a faint trace of a median longitudinal carina. Post-orbital ridges without anterior spines, swollen posteriorly. Carapace oval, punctate, granular on sides. Antero-lateral border not angulate or notched. No lateral or branchiostegian spines. Cervical groove sub-sinuate. Areola none. Abdomen longer than cephalothorax. Anterior segment of telson bispinose on each side, posterior segment round behind. Epistoma triangular. Antennæ short, with very small spines on the second and third segments, scale short, broad, inner margin rounded. Third maxillipeds hairy within and beneath. Chela moderate, hand inflated, punctate, ciliate, inner margin ornamented with a row of sharp

* The full figure of *C. Uhleri* was accidentally omitted by the artist.

dentiform tubercles, outside of which is a row of smaller tubercles. Fingers compressed, punctate and costate, movable finger with a single row of tubercles on the outer edge, a prominent rib running along the middle of the upper surface, inner margin excised at base and furnished with tuberculiform teeth; external finger toothed within, hairy at base, outer border marginate. Carpus armed with a strong tooth and a few small scattered tubercles on the inner side, a stout median anterior spine beneath, and two or three smaller ones between the median and internal spine. Superior border of meros serrate, inferior surface with two longitudinal rows of spines. Second pair of legs densely ciliate on the inner side near the tip. Third pair of legs hooked. First pair of abdominal appendages of male and annulus of female as in *C. Diogenes*.

Length, 65 mm. Carapace, 30.5 mm. Rostrum, 6.5 mm.

Known Localities. — Maryland: Caroline Co. (Coll. P. R. Uhler); Dorchester Co.; Talbot Co. (Coll. P. R. Uhler); St. Mary's Co. (Coll. P. R. Uhler); Wicomico Co. (Coll. P. R. Uhler); Somerset Co.; Worcester Co.

This species was discovered by Mr. P. R. Uhler, of Baltimore, in the counties of Maryland enumerated above, on the Chesapeake and Atlantic coasts of Maryland. It is found in salt marshes, covered twice daily by the tides, and also in brackish and fresh-water ditches in company with *C. Blandingii*. In Dorchester County it is found far back in the lowlands in the neighborhood of Vienna.

C. Uhleri is easily distinguished from *C. Diogenes* and *C. argillicola* by its plane rostrum, shape of the hand, etc.

30. Cambarus Girardianus.

Plate IV, fig. 1, Plate IX, figs. 2 a, 2 a'.

Cambarus Girardianus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 117, 1884.

Male, form II.—Rostrum broad, excavated, margins with a line of puncta, slightly convergent; acumen long, ending in a brown corneous upturned tip; a pair of minute, brown horny teeth at base of the acumen. Post-orbital ridges depressed, with sharp anterior spines. Cephalothorax as long as the abdomen. Carapace flattened above, densely and finely punctate, slightly granulated and finely ciliated on the branchial and hepatic regions. Cervical groove sulcate, sinuate, with minute lateral spine, and terminating with a small branchiostegian spine; external angle of the orbit

very prominent, ending in a spinule. Areola long and wide, plane, punctate, in length more than one half the distance between the tip of rostrum and posterior margin of the carapace; sides nearly parallel to within a short distance of the posterior margin, where they diverge. Telson bispinous on each side. Anterior process of epistoma broad. Antennæ longer than the body, scale moderately broad, ending in long, acute apical spine. Third pair of maxillipeds hairy within. Chelipeds moderate; chela large, densely punctate, inner margin short, lightly serrate; fingers long, with parallel rows of puncta, toothed within, outer one bearded within at base. Carpus broad, obliquely truncated, punctate above, with a strong median spine on the inner side and a small double one at the base; below, the carpus is armed with a spine on the anterior border. Meros smooth, with a single ante-apical spine on the upper edge; of the usual biserial spines beneath, only two or three at the proximal end are developed. Thoracic sterna naked. Third pair of legs hooked on the third segment. Fourth pair of legs with a small ovate basal tubercle. First pair of abdominal appendages articulated near the proximal end, stout, short, swollen in the middle; external part with the compressed apex in the form of a strong, obtuse, recurved tooth, double within; internal part recurved, cylindrical, short, acute.

Female.—Annulus ventralis transverse, with a sigmoid sulcus.

Measurements of an individual. — Length of body, 60 mm.; cephalothorax, 31 mm.; abdomen, 29 mm. From tip of rostrum to cervical groove, 20 mm.; from cervical groove to hind margin of carapace, 11 mm. Width of areola, 3.5 mm. Length of rostrum, 7.5 mm.; acumen of rostrum, 2.5 mm.; chela, 20 mm.; inner margin of hand, 7 mm.; fingers, 13 mm.; antennæ, 58 mm.

This species is near *C. extraneus*, but differs in its longer and narrower areola, in the short hand and long fingers, the single superior ante-apical spine on the meros, naked thoracic sterna (in *C. extraneus* they are setiferous), the greater smoothness of the body altogether, and the fineness of the punctation of the carapace; the suborbital angle is very much more projecting than in *C. extraneus*.

This species was discovered by Mr. C. L. Herrick in Cypress Creek, Lauderdale Co., Ala., when collecting under the auspices of the U. S. National Museum, in October, 1882. The specimens obtained were two males, form II., and three females.

31. Cambarus cornutus.

Plate V. figs. 1, 2, Plate IX. figs. 3, 3'.

Cambarus cornutus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 120, 1884.

Male, form I. — Rostrum long, narrow, excavated above; margins divergent at the base, thickened, concave, costate; acumen long, with upturned horny tip; lateral teeth at base of acumen upright, stout, blunt, horny. Post-orbital ridges sulcate on the outer side, with well-developed horny-tipped anterior spines. Carapace flat, smooth and punctate above, granulated on the sides; a depression on each side just outside the orbital ridges; no sub-orbital angle nor spine; cervical groove sulcated, sinuate, with a strong, sharp lateral spine; no branchiostegian spine; areola long, of moderate width, plane, punctate, widening at the posterior end of the carapace. The length of the areola is equal to the distance from the cervical groove to the base of the rostrum. Abdomen broad, as long as the cephalothorax without the acumen of the rostrum, pleura triangular, with sharp lateral angles. Terminal segment of telson broader than long, posterior border rounded; anterior segment of telson bispinous on each side. Anterior process of epistoma very broad, short, triangular; apex not truncated nor notched. Thoracic sterna ciliated. Basal segment of antennule with a spine on lower side on the distal half of the segment. Antennæ longer than the body, flagellum very large, composed of annulations flattened in the vertical direction, conspicuously bearded along the inner margin. Antennal scale oblique to the horizontal plane of the body, a little longer than the rostrum, inner margin straight and parallel with the outer margin, subtruncate at the tip, apical spine strong, long and acute; second segment of antenna with a large external spine at base of the scale; another small but well-formed external spine on the following segment below. Chelipeds large. Chela of moderate size; hand smooth, punctate, internal margin serrate; fingers of moderate length, curved slightly downwards, ribbed and punctate above, tips incurved, horny; external finger serrate on outer margin, impressed above and below at base; inner borders of fingers tuberculate and ciliated especially at their bases. Carpus smooth, lightly punctate above, with a strong median internal spine and a small basal internal spine; a sharp, prominent median anterior spine beneath. Meros smooth, a single acute ante-apical spine on the superior margin, only one or two distal spines in the outer row of biserial spines

beneath. Third joint of third pair of legs hooked. Fourth pair of legs with a conical tubercle on the first segment. First pair of abdominal appendages short, stout, twisted, distal half bent in towards the median line of the body; internal part truncate at apex, with a small spine directed backward and outward; external part longer, ending in a short, recurved, blunt, laterally compressed, horny tooth.

Measurements. — Length of body, 81 mm.; of cephalothorax, 43.5 mm.; of abdomen, 37.5 mm. From tip of rostrum to cervical groove, 27 mm.; from cervical groove to posterior border of carapace, 16 mm. Length of rostrum, 11 mm.; of acumen of rostrum, 5 mm.; of antennæ, 91 mm.; of chela, 36 mm.; of movable finger, 22 mm. Width of base of acumen of rostrum, 3 mm.; of areola, 3 mm.; of chela, 15 mm.

One specimen, collected by Mr. F. W. Putnam in Green River, near the Mammoth Cave, Ky., November 3, 1874.

This species is very distinct from every other known crayfish. In its general appearance it approaches those species included in the group typified by *C. Bartonii*. The rostrum, however, is more after the fashion of *C. rusticus*, but the lateral spines are much larger and stand erect. The impressed external finger recalls *C. Bartonii*, var. *robusta*. The sexual appendages are formed nearly as in *C. Bartonii*. The development of the antennæ is extraordinary.

32. Cambarus hamulatus.

Plate IV. fig. 6, Plate IX. figs. 1 a, 1 a'.

Orconectes hamulatus, Cope and Packard, Amer. Naturalist, XV. 881, Pl. VII. figs. 1, 1*a*, 1*b*, Nov. 1881.
Cambarus hamulatus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 115, 1884.

Male, form II. — Rostrum long, subexcavated, foveolate at base, margins moderately raised, converging, lateral spines strong and acute; acumen long, narrow, acute. Post-orbital ridges slightly developed, impressed without; with prominent acute anterior spines. Carapace subcylindrical, flattened above, region posterior to cervical groove long; smooth above, granulated on the sides. A sharp spine on each side at the base of the antennæ at the anterior extremity of the cervical groove, and two or three on each branchial region just behind the cervical groove, one of which is prominent, the other minute. Areola of moderate width, sparsely punctate, sides parallel. Abdomen longer than the cephalothorax, equal to the cephalothorax in width.

Telson long, proximal segment bispinose on each side, distal segment elliptical. Anterior process of epistoma obtusely subtriangular. Eyes rudimentary, concealed under the rostrum. Basal segment of antennules furnished with a sharp spine beneath near the distal extremity. Antennæ shorter than the body, scale equal to the rostrum in length, broad, broadest at the distal end, external border slightly convex, inflated, produced into a long, acute spine. Third pair of maxillipeds bearded within. Chelipeds slender, chela long, slender, subcylindrical, slightly pubescent, inner margin straight, subdentate. Fingers long, slender, subcostate, inner margin straight, hairy. Carpus long, inner side tuberculate, with a sharp anterior spine; two spines on the anterior margin of the lower surface. Upper margin of the meros granulated, with two sharp spines near the distal end; lower surface of the meros furnished with sharp spinules arranged biserially. Third pair of legs hooked. First pair of abdominal appendages fashioned after the type of the *C. Bartonii* group, articulated near the base, short, dilated in the middle, tip bifid, recurved; inner and outer parts forming recurved hooks, the tip of the inner attenuated; outer part double within. The curve of the terminal hooks is not so strong as in *C. Bartonii* and allied species, and the two are closely approximated instead of being separated.

Female. — Body stouter, sternum between the fourth pair of legs smooth, annulus ventralis broad, with a raised rim on the posterior margin, and a wide longitudinal sulcus anteriorly.

Measurements of male, form II. — Length, 44 mm.; of carapace, 21 mm.; of rostrum, 5 mm.; of acumen of rostrum, 2.5 mm. From tip of rostrum to cervical groove, 12 mm.; from cervical groove to posterior border of carapace, 9 mm. Length of abdomen, 23 mm.; of antennæ, 35 mm.; of cheliped, 31 mm.; of chela, 15 mm. Breadth of chela, 3 mm.; of carapace, 8 mm.

Locality. — Nickajack Cave, Tennessee.

I am indebted to Professor Packard for an opportunity to examine four males, form II., and two females of this species, which was discovered by Professor Cope while exploring Nickajack Cave, in the southern part of Tennessee, near the point where the boundary of that State is met by the line which divides the States of Georgia and Alabama. In general form and appearance it bears a close resemblance to *C. pellucidus*, but the carapace is less spiny, and the male has hooks on the third pair of legs only, and the first pair of abdominal appendages are formed after the fashion of the *C. Bartonii* group. The rostrum tapers towards the tip more than it does in the

typical form of *C. pellucidus*, resembling in this respect the form *C. pellucidus inermis*. The terminal segment of the telson narrows at the hinder end more than in *C. pellucidus*. I do not find the differences in the mandibles, antennal scales, and chelæ mentioned by Packard.

33. Cambarus Jordani.

Plate III. fig. 3.

Cambarus Jordani, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 119, 1884.

Male, form II. — Rostrum broad, subplane, sides nearly parallel, acumen long, with minute lateral teeth at base. Post-orbital ridges provided with sharp anterior spines. Carapace punctate (sparsely so on the gastric region), slightly granulated on the sides. A single acute spine on each side of the carapace behind the cervical groove, and a branchiostegian spine on the anterior border. Sub-orbital angle prominent. Areola long, narrow, widening gradually anteriorly, suddenly posteriorly, smooth, with but few puncta irregularly disposed in its field. Abdomen longer than the cephalothorax; proximal segment of the telson bispinous, distal segment rounded posteriorly. Epistoma triangular. Antennæ equal in length to the body minus the telson, scale broad, greatest width toward the distal end, which is sub-truncate and furnished with a sharp external spine. Third pair of maxillipeds hairy within. Chela punctate, ciliate; inner margin of hand short, serrate; fingers long, costate, outer border of movable one serrato-tuberculate. Carpus with a strong, acute median spine, and a small basal spine on inner border; a small spine at each articulation with the chela. Meros smooth on the external surface, two ante-apical spines obliquely placed on the upper edge. First pair of abdominal appendages short, thick, articulated near the base, terminating in two blunt, recurved teeth.

Length of body, 47 mm.; of carapace, 23 mm.; of abdomen, 24 mm.; of rostrum, 6 mm.; of acumen of rostrum, 2 mm. From point of rostrum to cervical groove, 15 mm.; from cervical groove to hind margin of carapace, 8 mm. Width of areola, 1.3 mm. Length of antennæ, 44 mm.

Of this species I have seen but one specimen, a male of the second form, collected by Prof. D. S. Jordan in the Etowah River near Rome, Georgia, communicated by Mr. P. R. Uhler, of Baltimore. It has a toothed rostrum and first abdominal appendages like *C. Bartonii*. It is distinguished from the other allied species by its flat rostrum and narrow areola.

34. Cambarus extraneus.

Cambarus extraneus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 73, Pl. I. figs. 88, 89, Pl. III. fig. 156, 1870.
Cambarus extraneus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 145, 1884.

Known Localities.—Tennessee River near the border of Georgia. Etowah River, Rome, Ga.

Cambarus extraneus, *Girardianus*, *Jordani*, *cornutus*, and *hamulatus* agree in combining the toothed rostrum of the *C. affinis* group with male appendages formed as in the *C. Bartonii* group. The third pair of legs alone are hooked. *C. hamulatus* is at once distinguished by its rudimentary eye-stalks, the great length of the posterior segment of the carapace, and long and slender chelæ. It has the superficies of *C. pellucidus*. *C. cornutus* has strong, erect, lateral rostral teeth, and very thick antennal flagellum, heavily bearded on inner side. *C. Jordani* has a narrow areola with but a few scattered dots, and the antennal scale is broadest toward its tip. *C. extraneus* and *C. Girardianus* have a wide areola thickly sown with dots; they are closely related, but may be separated as follows. In *C. extraneus* the areola is broader and shorter than in *C. Girardianus*; while in *C. extraneus* the section of the carapace behind the cervical groove is never more, usually less, than one third of the entire length of the carapace from tip of rostrum to posterior border, in *C. Girardianus* this section of the carapace is more than one third of the length of the entire carapace. The punctation of the carapace is much coarser in *C. extraneus* than in *C. Girardianus*. The lateral spine of the carapace is very prominent in *C. extraneus*, rudimentary in *C. Girardianus*. In *C. Girardianus* the external orbital angle is very prominent, and ends in an acute spine with a corneous tip; the fingers are longer in proportion to the hand than in *C. extraneus*. The distal end of the meros has a single spine on the upper edge in *C. Girardianus*; *C. extraneus* has two obliquely placed.

Of *C. extraneus* I have seen nine specimens, of *C. Girardianus* five, of *C. Jordani* one, of *C. hamulatus* six. Among these are males of the second form with the first abdominal appendages articulated and not articulated, but no males of the first form.

The larger female mentioned by Hagen, p. 74, is *C. spinosus* Bundy.

The largest specimen of *C. extraneus* seen by me, a male, form II., with articulated first abdominal appendages, is in the possession of Butler Uni-

versity, Irvington, Ind. It was collected by Jordan in the Etowah River, at Rome, Ga. It measures $3\frac{3}{8}$ inches in length. The areola in this specimen is a little longer and less dilated posteriorly than in the types from the Tennessee River.

The antennæ (mutilated in the type specimens) are nearly as long as the body.

C. extraneus has been found in but two localities, in both places in company with *C. spinosus*.

GROUP IV. (Type, C. affinis.)

Third segment of the third pair of legs of the male hooked. First abdominal appendages of the male bifid, terminated by two nearly straight styliform branches.

Rarely a specimen of *C. virilis* and *C. propinquus* is found with hooks on the third segment of the second, as well as the third, pair of legs, but normally only the third legs are provided with hooks.

The first pair of abdominal appendages in the male are bifid, ending in two free styliform rami. The rami are short, so that the tips reach forward only to the base of the third pair of legs in *C. affinis, Sloanii, lancifer, propinquus*, and *Harrisonii*, while in the other species of the group the rami are elongated to such a degree that they reach forward as far as the base of the second pair of legs, or even to the chelipeds when the abdomen is flexed. In *C. immunis, Alabamensis, Palmeri, Mississippiensis*, and *compressus* the distal part of the long rami is strongly recurved. In *C. lancifer* the terminal rami are short, the outer part almost tooth-like, so that the character of the appendage approaches the type seen in the species belonging to Group I. The shape of the rostrum, antennal scales, and chelæ also mark *C. lancifer* as a passage form between Group I. and Group IV.

The rostrum is commonly armed with a lateral spine in this group, but in *C. medius, C. immunis*, and *C. Mississippiensis* the margins of the rostrum are entire, at least in full-grown individuals.

This group corresponds to Hagen's Group II.

The following artificial key may aid in the determination of the species in this group.

- Rostrum without lateral teeth (at least in the adult).
  - Areola linear in the middle. *C. Mississippiensis.*
  - Areola not linear in any part. *C. medius, C. immunis.**
- Rostrum with lateral teeth.
  - Areola linear in the middle.
    - Rostrum and antennal scales very long. *C. lancifer.*
    - Rostrum and antennal scales of moderate length. *C. Palmeri.*
  - Areola of moderate width.
    - Rostrum with a median carina above. *C. Alabamensis, C. compressus, C. propinquus.*
    - Rostrum not carinated.
      - Sides of carapace armed with numerous spines. *C. affinis.*
      - Only one lateral spine on carapace (sometimes obsolete).
        - Rostrum but slightly excavated, or sub-plane. *C. virilis, C. propinquus*, var. *obscura, C. Sloanii.*
        - Rostrum deeply excavated, with raised margins.
          - Margins of rostrum concave. *C. Harrisonii, C. rusticus, C. forceps.*
          - Margins of rostrum straight. *C. propinquus*, var. *Sanbornii, C. spinosus, C. Putnami.*

35. Cambarus lancifer.

Cambarus lancifer, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 59, Pl. I. figs. 86, 87, Pl. III. fig. 159, 1870.
Cambarus lancifer, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 146, 1884.

The only specimen of this species known is Hagen's type from Root Pond, Miss. I cannot find in what part of the State Root Pond is situated.

36. Cambarus affinis.

? *Astacus limosus,* Rafinesque, Amer. Monthly Mag. and Critical Rev., II. 42, Nov. 1817.
Astacus affinis, Say, Journ. Acad. Nat. Sci. Phila., I. 168, Dec. 1817.
Astacus affinis, Harlan, Medical and Physical Researches, p. 230, fig. 2, 1835.
Astacus Bartonii, Milne Edwards, Histoire Naturelle des Crustacés, II. 331, 1837.
Astacus affinis, De Kay, Zoölogy of New York, Part VI. Crustacea, p. 23, 1844. (After Say.)
? *Astacus (Cambarus) affinis,* Erichson, Arch. f. Naturgesch., Jahrg. XII., I. 96, 1846.
Cambarus affinis, Girard, Proc. Acad. Nat. Sci. Phila., VI. 87, 1852. (Young.)
Cambarus Pealei, Girard, Proc. Acad. Nat. Sci. Phila., VI. 87, 1852. (Adult.)
Cambarus affinis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 60, Pl. I. figs. 19–22, 84, 85, Pl. III. fig. 152, Pl. V., 1870.
Cambarus affinis, Abbott, Amer. Naturalist, VII. 80, 1873. (Habits.)
Cambarus affinis, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 638, 1874. (After Hagen and Abbott.)
Cambarus affinis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 146, 1884.

Known Localities. — New York: Niagara. New Jersey: Schooley's Mountain, Morris Co.; Red Bank, Monmouth Co. (Coll. Acad. Nat. Sci. Phila.); Trenton; Burlington; Camden Co. (Coll. Acad. Nat. Sci. Phila.). Pennsyl-

* There is a variety of *C. immunis* with lateral rostral spines. See p. 99.

vania: Brandywine Creek (Coll. Acad. Nat. Sci. Phila.); Schuylkill (Coll. Acad. Nat. Sci. Phila.); Reading (Girard); Philadelphia (Coll. Acad. Nat. Sci. Phila.); Bristol; Susquehanna River (Coll. U. S. Nat. Mus.); Bainbridge (Coll. U. S. Nat. Mus.); Carlisle. Maryland: Cecil Co.; Havre de Grace, Harford Co.; Guynn's Falls, Druid Hill, etc., Baltimore Co. (Coll. P. R. Uhler); Anne Arundel Co. (Coll. P. R. Uhler); Montgomery Co.; Charles Co., Potomac River (Coll. P. R. Uhler); Williamsport, Washington Co. (Coll. P. R. Uhler); Cumberland, Alleghany Co. District of Columbia: Washington, Potomac River (Coll. U. S. Nat. Mus.). Virginia: Gunston, Potomac River, Fairfax Co. (Coll. U. S. Nat. Mus.). ~~Lake Erie (Coll. Peabody Acad. Sci.).~~ Lake Superior (Coll. Bost. Soc. Nat. Hist.).

Rafinesque's description of *Astacus limosus* is as follows: —

"N. Sp. *Astacus limosus*. Antens length of the thorax, rostrum equal to their peduncle, one-toothed on each side, canaliculated at its base; a thorn above the eyes, another on each flank, three pairs of pinciferous feet, bearded at their articulations, hands short, smooth, unarmed. — Obs. I discovered this species in 1803, and observed it again in 1816, in the muddy banks of the Delaware, near Philadelphia; vulgar name, mud lobster; length from three to nine inches; good to eat; commonly brown, with an olivaceous tinge."

From the habitat it is probable that this imperfect description refers to the species well described in the following month by Say under the name of *A. affinis*, as assumed by Girard and Hagen.

A dry male specimen in the Academy of Natural Sciences of Philadelphia, No. 127 [b], "Schuylkill. Dr. Harlan," is probably Harlan's type.

Milne Edwards, apparently misled by the transposition of the numbers of Fig. 2 and Fig. 3 on Harlan's plate, has described this species as *Astacus Bartonii*; *A. Bartonii* as *A. affinis*.

Erichson's type, a female, in the Berlin Museum, was examined by Hagen in September, 1870. The specimen is stated by Erichson to have been collected in Carolina by Cabanis. The label only gives *America borealis*. Dr. Cabanis assured Dr. Hagen that he collected all his Astacidæ in a rivulet near Greenville, in the northwestern part of South Carolina. No other specimen of *C. affinis* has been reported from that State, and I suspect that Erichson's type belongs to the closely allied *C. spinosus* Bundy, which has been found in the Saluda River, S. C., by Prof. D. S. Jordan. In the museum of the Academy of Natural Sciences is a specimen of this species (No. 127)

from Red Bank, N. J., Dr. Jos. Leidy, labelled "*A. affinis* (*fide* L. R. Gibbes)." Gibbes states that his own specimens came from Florida. They probably belonged to some other species. Hagen states that Gibbes's types of *A. Bartonii* in the Academy of Natural Sciences of Philadelphia are *C. affinis*, but they are in fact *C. placidus* Hagen (Nos. 126[a], 126[c]).*

Types, male and female, of Girard's *C. affinis*, from Reading, Pa., collected by Professor Baird, were communicated to Dr. Hagen by Dr. Stimpson. The male belonged to the second form; the specimens were young, with only one lateral thoracic spine. I have myself discovered in the collection of the Smithsonian Institution four types (two males, two females) of *Cambarus Pealei* Girard (Smithson. Cat. No. 2081), from the Potomac River, Washington. The largest is $4\frac{1}{4}$ in. in length, the smallest $3\frac{1}{8}$ in. They are the adult *C. affinis* Say. These are the only types of Girard's Cambari now in existence, as far as I can discover. The rest were probably burned when loaned to Stimpson, in the great fire of Chicago.

Color. — Upper surface greenish, mottled with darker green, especially on the chelæ; tips of fingers orange, preceded by a dark green ring, which runs along the outer border of the hand to the wrists; abdominal somites ornamented with interrupted transverse chestnut-colored double bands. Under surface of a lighter hue. In recent alcoholic specimens the bands of the abdomen turn bright blood-red.

In some specimens the basal segment of the telson has *three* spines on each side of its posterior margin.

The centre of distribution of *C. affinis* appears to be the great rivers which empty into the Delaware and Chesapeake Bays.

According to Dr. C. C. Abbott (American Naturalist, VII. 80, 81), "*Cambarus affinis* is apparently *the* river species at Trenton, N. J. We have been able to find it, as yet, only in the Delaware River, usually frequenting the rocky bed, but also, in fewer numbers, on the mud-bottomed portions of the river. They are usually found resting under flat stones, well out from the banks of the stream, where the water is of considerable depth. Wherever the vegetation is dense we have failed to find them; nor have we seen anything to indicate that it is a burrowing species."

Since this was written, Dr. Abbott and myself have taken *C. affinis* in great numbers from shallow ditches in the Delaware meadows near Trenton, N. J., in company with *C. Blandingii*.

* See p. 114.

According to Mr. P. R. Uhler, *C. affinis* is the common form in the warmer parts of the rivers and creeks of Maryland, underneath stones. In his collection are specimens from Montgomery Co., labelled as found in "stagnant pools," and specimens from Alleghany Co., four miles below Cumberland, were taken from "holes in the bottom and sides of a canal."

A female alcoholic specimen of *C. affinis* in the Academy of Natural Sciences of Philadelphia is labelled "Santo Domingo, W. M. Gabb." The locality is doubtless erroneous.

In young specimens of *C. affinis* the lateral thoracic spine on the cervical groove is single, and the spinules of the hepatic region are reduced to a mere granulation. Very small individuals closely resemble small examples of *C. propinquus*, as Hagen observes. The body, however, in the young *C. affinis* is more pubescent, the rostrum is not carinated, and the hand is differently shaped. The specimens in the Museum of Comparative Zoölogy from Niagara, referred to *C. affinis* by Hagen, are all very young (the largest measuring $1\frac{3}{8}$ in.), but I think there is no doubt of the correctness of the determination.

C. affinis is the common crayfish exposed to sale in the markets of New York and other Eastern cities.

37. Cambarus Sloanii.

Plate IV. fig. 5, Plate X. figs. 1, 1', 1 a, 1 a'.

Cambarus Sloanii, Bundy, Bull. Ill. Mus. Nat. Hist., No. I. p. 24, 1876. — Proc. Acad. Nat. Sci. Phila., 1877, p. 172.
Cambarus Sloanii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 147, 1884.

Male, form I. — Rostrum wide, subexcavated, plane towards the tip, margins nearly parallel, acumen long, triangular; lateral teeth small in full-grown specimens, in some individuals reduced to an angle merely. Post-orbital ridges with very small anterior spines, or none. Carapace flattened above, punctate, lightly granulate on the sides, lateral spines acute, anterior border distinctly angulated, areola wide. Basal segment of telson two-spined on each side. Antennal scale a little longer than the rostrum, of moderate width. Anterior process of epistoma broad, excavated, emarginate in front. Third pair of maxillipeds hairy within, naked below. Chela short, broad, inner margin with a double series of depressed teeth; outer finger wide at base, furrowed above near the outer and inner margins; inner finger

curved, costate above; the two fingers are furnished with blunt tubercles on their opposed margins, which touch one another only at their tips. Carpus with a strong inner tooth. Third pair of legs hooked. First pair of abdominal appendages stout, bifid; rami short, acute, outer one with its tip turned outwards, inner one with its tip turned inwards; tips brown, horny.

Male, form II. — The fingers are less gaping, the hooks on third pair of legs small, the first pair of abdominal appendages are bifid for a less distance from the tip, the rami are swollen, without horny tips; these appendages may or may not be articulated near the base.

Female. — Chela like that of the male, form II. Annulus ventralis with anterior border depressed, posterior border elevated, tuberculate, tubercle divided longitudinally by a sinuous furrow.

Known Localities. — Indiana: New Albany. Kentucky (Bundy).

I have seen two of the types of this species, male form I. and female, in the collection of the Peabody Academy of Science, Salem, Mass. Dr. Sloan has also sent me specimens taken at the same time with those sent to Bundy for description, and there are specimens from the same source in the collections of the Boston Society of Natural History, the Peabody Museum of Yale College, and Butler University, Irvington, Ind.

Dr. Sloan writes me that this is the common species in running streams at New Albany, while *C. Bartonii* is the form found in still waters. According to the same gentleman, as quoted by Bundy, this is a burrowing species. "He commences on the bank of the stream, burrows below the bed, and has an opening two or more feet out in the stream, where he sits watching for anything that may turn up, with a safe retreat."

C. Sloanii closely resembles *C. propinquus*, var. *obscura*, in general appearance, but may be at once distinguished by the male appendages and the annulus ventralis of the female. In the latter species the anterior border of the annulus is prominently bituberculate, whereas in *C. Sloanii* the anterior rim is sunk below the level of the sternum in front of it.

The largest specimen seen by Bundy measured $3\frac{1}{2}$ inches in length. The largest I have seen, a female, is a little less than three inches long.

38. Cambarus propinquus.

Cambarus propinquus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 88, 1852.
Cambarus propinquus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 67, Pl. I. figs. 31–38, Pl. III. fig. 153, 1870.
Cambarus propinquus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 638, 1874. (No description.)
Cambarus propinquus, Forbes, Bull. Ill. Mus. Nat. Hist., No. I., pp. 4, 19, 1876.
? *Cambarus propinquus*, Bundy, Proc. Acad. Nat. Sci. Phila., 1877, p. 171. — Trans. Wis. Acad. Sci., V. 181, 1882. — Geol. Wis., Surv. 1873–79, I. 102, 1883. (No description.)
Cambarus propinquus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 147, 1884.

Known Localities. — Dominion of Canada: Montreal (Coll. Peabody Mus. Yale Coll.); Toronto. New York: Grass River, St. Lawrence Co. (Hagen); Canton, St. Lawrence Co. (Coll. L. A. Lee); Black Lake, St. Lawrence Co.; Ogdensburg (Coll. U. S. Nat. Mus., Young); Lake Ontario (Girard); Garrison Creek, Sackett's Harbor (Girard); Four-Mile Creek, Oswego (Girard); Oneida Lake; Cayuga Lake (S. I. Smith); Rochester; Niagara; Forestville, Chautauqua Co. Indiana: Elkhart River, Rome City, Noble Co. (Bundy); Delphi; Indianapolis (Coll. Peabody Acad. Sci.); Michigan City (Coll. Acad. Nat. Sci. Phila.); Turman Creek, Sullivan Co.; Clear Creek, Bloomington; White River (Coll. Bost. Soc. Nat. Hist.); Switz City (Coll. C. H. Gilbert). Illinois: Freeport, Stephenson Co. (Forbes); Ogle Co.; Geneva, Kane Co. (Coll. Peabody Mus. Yale Coll.); Pekin, Tazewell Co. (Forbes); Normal, McLean Co. (Forbes); Decatur, Macon Co.; Aux Plains River (Coll. U. S. Nat. Mus.). Michigan: St. Clair River; Detroit River; Northville (Coll. U. S. Nat. Mus.); Huron River, Ann Arbor (Coll. Bost. Soc. Nat. Hist., Peabody Acad. Sci., Acad. Nat. Sci. Phila.); Ecorse (S. I. Smith); Kalamazoo River, Otsego (Coll. Bost. Soc. Nat. Hist.). Lake Superior. Wisconsin: tributaries of Pecatonica River, Green Co.; Madison (Coll. Peabody Mus. Yale Coll.). Iowa: Davenport; Des Moines River, Ottumwa.

Var. Sanbornii.

Plate V. fig. 3, Plate IX. figs. 10, 10, 10 a, 10 a.

Cambarus Sanbornii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 128, 1884.

Known Localities. — Kentucky: Smoky Creek, Carter Co. Ohio: Oberlin.

Var. obscura.

Cambarus obscurus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III., p. 69, Pl. I. figs. 72–75, Pl. III. fig. 154, 1870.

Cambarus obscurus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (After Hagen. No description.)

Cambarus obscurus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 148.

Known Localities. — Genesee River, Rochester, New York.

Girard's diagnosis of *C. propinquus* is too imperfect to avail in the determination of the species, but fortunately Dr. Hagen identified it by examination of one of Girard's types.

In the Academy of Natural Sciences of Philadelphia there is a dry male specimen of *C. propinquus* which was labelled "*C. Diogenes*? District of Columbia," when the collection was examined by Hagen. The original label of this specimen is now lost, but the box contains Dr. Hagen's label, "*C. propinquus* Gir. (*C. Diogenes* Gir.?)," and the tablet to which the specimen is fastened carries a label with the locality "District of Columbia." A dry specimen of *C. obesus* Hag. in the same museum is labelled "*C. propinquus*? Garrison Creek, Sackett's Harbor." The labels of these two specimens were undoubtedly transposed by accident.

I am not sure that Bundy's *C. propinquus* is this species, as I have not seen his types. He says that there is "in these crawfishes a tendency manifested toward multiplication of the lateral thoracic spines, there being in some individuals two and in others three of these on each side." This tendency does not appear in any specimens that I have seen. It is an abundant species in Wisconsin, in company with *C. virilis*.

Smith says that the crayfish found in the valley of the Aroostook River in Maine and New Brunswick is most likely *C. propinquus*. It is really *C. Bartonii*.

In the variety that I have named after the late Mr. F. G. Sanborn (*C. Sanbornii*, Proc. Amer. Acad. Arts and Sci., XX. 128) the first abdominal appendages are less deeply bifid, the rami closer together, than in the typical *C. propinquus*. The rostrum is not carinate, the chela is finely pubescent, the inferior median anterior spine of the carpus is evident. This variety was collected by Mr. Sanborn in Carter Co., Ky., and I have received additional specimens from Prof. B. F. Koons collected at Oberlin, Ohio. Small individuals closely resemble young specimens of the typical *C. propinquus*,

C. affinis, and more closely *C. Putnami;* but the young of the first may be distinguished by the carinated rostrum; of the second, by the longer rostral acumen, antennal scale, and anterior spine of post-orbital ridge, by the longer hand and internal carpal spine, and by the divergent tips of the first pair of abdominal appendages in the male; of the third, by the longer-spined antennal lamina, and the long, deeply cleft abdominal appendages of the male.

In *C. obscurus* Hag., which I deem a local form of *C. propinquus*, the rostrum is somewhat broader, not carinate above, and less deeply hollowed out than in the typical *C. propinquus;* the hand is broader, with a few tubercles disposed in a longitudinal row opposite the base of the movable finger; the fingers are more widely separated at the base, the epistoma more truncate; the male appendages have a projecting angle or shoulder on the anterior margin at the base of the rami, the outer part often grooved longitudinally on the outer side. This form has been discovered only at Rochester, N. Y. The differences between it and *C. propinquus* are so slight that I consider it only a variety. Some specimens of *C. propinquus* show a strong tendency to develop the projecting shoulder on the front border of the male appendages.

In the United States National Museum is a small first-form male of a Cambarus labelled "California" (No. 2531), which I cannot distinguish specifically from *C. obscurus*. The areolar part of the back of the carapace is a little flatter, and the row of small tubercles on a line with the middle of the base of the movable finger is not apparent; but this often happens in small specimens of *C. obscurus*. The locality of this specimen is very probably erroneous, as no other specimen of a Cambarus from the west coast is known.

Hagen thinks that *C. obscurus* may be the *Astacus fossor* of Rafinesque. Rafinesque's description is as follows: —

"*Astacus fossor*. Antens length of the body, rostrum short, one-toothed on each side, a thorn behind the eyes; three pairs of pinciferous feet, hands of the first pair very large, granular, gaping, toothed, with a furrowed and bispinous wrist. — Obs. Vulgar name, burrowing lobster, — communicated to me by Dr. Samuel L. Mitchill, — native of Virginia, Pennsylvania, and New York; size from four to six inches; it burrows in meadows and milldams, which it perforates and damages."

It is impossible to determine what species is here meant. The description would suit *C. propinquus*, a commoner form, as well as *C. obscurus*.

Neither of these forms has been reported from Pennsylvania or Virginia. The only species known to me to be common to the three States of New York, Pennsylvania, and Virginia are *C. Blandingii*, *affinis*, and *Bartonii*. Rafinesque's description fits none of them. Girard surmised, from the habits of *C. fossor*, that it might prove to be *C. Diogenes*.

In the collections of the Boston Society of Natural History and the Museum of Comparative Zoölogy (Cat. No. 3590) there are three second-form males of a Cambarus which closely resemble *C. propinquus*, but the sexual appendages are longer, as in *C. rusticus*. The epistoma is long. The carpus has a strong internal median carpal spine and a small basal internal spine; beneath, the carpus is unarmed. The biserial spines of the meros are well developed. The outer ramus of the first abdominal appendages is a little recurved at the tip. The largest of these specimens is 75 mm. long. No locality is given. They seem to belong to an undescribed species.

39. Cambarus Harrisonii.

Plate III. fig. 1, Plate IX. figs. 9, 9.

Cambarus Harrisonii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 130, 1884.

Male, form I. — Rostrum long, narrow, deflexed, excavated; margins thickened, a little convergent; acumen of moderate length, triangular, acute; marginal spines short, obtuse, often obsolescent. Carapace flattened above, coarsely punctate, granulate on the sides; post-orbital ridges prominent, sulcate without, with acute anterior spine; antero-lateral margin notched at base of antenna; cervical suture not sinuate, interrupted on the side; lateral spine small, acute; branchiostegian spine obsolete; areola at least one half as long as the distance from the tip of the rostrum to the cervical groove, of moderate width, punctate, the dots tending to a biserial arrangement in the middle portion. Abdomen as long as the cephalothorax; telson long, posterior margin rounded, posterior margin of basal segment bispinous on each side. Basal segment of antennule with an internal, subapical, inferior spine. Antennæ as long as the body; second segment armed with a short, acute, external spine; scale as long as the rostrum, of moderate width, widest near the middle, thence tapering to the acute external apical spine. Anterior process of epistoma with convex sides, apex blunt or truncate. Third pair of maxillipeds hairy within. Chelipeds of moderate length, thick; chela large, broad, coarsely punctate above and below, inner margin

of hand with two or three rows of depressed ciliate tubercles; fingers costate and punctato-lineate, gaping, inner margins with rounded tubercles; movable finger incurved; carpus punctate above, armed with an acute median internal spine and two inferior spines (a large median and a minute external). In some specimens there are one or two small antennal basal tubercles. Meros smooth without, two obliquely disposed superior sub-apical spines; of the biserial inferior spines only a few of the distal ones in each row are developed. Distal end of second pair of legs ciliate. Third segment of third pair of legs hooked. First pair of abdominal appendages short, reaching to the base of third pair of legs, thick, split for a short distance from the tip; outer part longer than the inner; tips recurved, brown and horny.

Female. — Fingers less widely gaping, outer one ciliate within at base. Abdomen broader. Sternum between fourth thoracic legs smooth. Annulus ventralis a transverse ridge, thickest in the middle, where there is a rounded tubercle divided longitudinally by a sinuous groove. Between the ridge and the sternal plates of the fourth pair of legs there is a deep transverse fossa.

Measurements of a male, form I. — Length of body, 60 mm. Length of carapace, 30 mm. Length of abdomen, 30 mm. From end of rostrum to cervical suture, 20 mm. From cervical suture to posterior border of carapace, 10 mm. Length of rostrum, 10 mm. Breadth of rostrum at base, 4 mm. Length of rostral acumen, 3 mm. Width of areola, 1.5 mm. Length of antennæ, 60 mm. Length of chela, 25 mm. Breadth of chela, 12 mm. Length of movable finger, 17 mm. Internal border of hand, 7 mm.

In one specimen, a male, form I., the fingers are very much elongated, not gaping at base. The length of the internal border of the hand in this specimen is 7.5 mm.; the length of the movable finger, 21 mm.

Locality. — Irondale, Mo. Collected by E. Harrison.

This species resembles *C. rusticus* in its general form. The male appendages, as well as the annulus ventralis of the female, however, are very different from those of any previously described species. The male appendages approach in form those of *C. propinquus* more nearly than any other, but in that species these appendages are more deeply bifid, and not recurved.

The second form of the male is unknown.

40. Cambarus virilis.

Cambarus virilis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 63, Pl. I. figs. 23–28, Pl. II. figs. 128–132, Pl. III. fig. 155, Pl. VIII., 1870.

Cambarus virilis, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 638, 1874. (After Hagen. No description.)

Cambarus virilis, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. pp. 4, 19, 1876.

Cambarus debilis, Bundy, Bull. Ill. Mus. Nat. Hist., No. 1. p. 24, 1876. — Trans. Wis. Acad. Sci., V. 181, 1882. — Geol. Wis., Surv. 1873–1879, I. 403, 1883. (Male, form II.)

Cambarus virilis, Bundy, Proc. Acad. Nat. Sci. Phila., 1877, p. 171. — Trans. Wis. Acad. Sci., V. 180, 1882. — Geol. Wis., Surv. 1873–1879, I. 402, 1883.

Cambarus Couesi, Streets, Bull. U. S. Geolog. Geograph. Surv. Terr., III. 803, 1877.

Cambarus virilis, Streets, Bull. U. S. Geolog. Geograph. Surv. Terr., III. 804, 1877.

Cambarus virilis, Herrick, Tenth Ann. Rep. Geolog. Nat. Hist. Surv. Minnesota, p. 253, 1882.

? *Cambarus Coueksi*? Bundy, Geol. Wis., Surv. 1873–1879, I. 402, 1883. (No description.)

Cambarus virilis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 147, 1884.

Known Localities. — Dominion of Canada: Lake Winnipeg; Saskatchewan River; Red River of the North; Toronto (Peabody Acad. Sci.); Montreal (?). Dakota: Red River of the North near Pembina; Souris or Mouse River. Minnesota: Lake Superior (C. L. Herrick); Mississippi River (C. L. Herrick); Lake Minnetonka (C. L. Herrick), Minnehaha Creek, Cedar Lake (Coll. U. S. Nat. Mus.), Bassett's Creek (Coll. U. S. Nat. Mus.), and Lake Independence, Hennepin Co. Wisconsin: Appleton; Ironton, Baraboo River; Sauk City, Wisconsin River (W. F. Bundy); Sugar River (Coll. Peabody Acad. Sci.); Rock River (S. A. Forbes); Jefferson (W. F. Bundy); Milwaukee (Coll. U. S. Nat. Mus.). Iowa: Davenport; Burlington; Fort Dodge (Coll. Bost. Soc. Nat. Hist.); Spring Vale (Coll. Peabody Acad. Sci.); Des Moines River (Coll. U. S. Nat. Mus.); Bedford (Coll. U. S. Nat. Mus.). Nebraska: Omaha. Wyoming: near Laramie City. Kansas: Leavenworth (Coll. Acad. Nat. Sci. Phila.); Manhattan (Coll. Acad. Nat. Sci. Phila.); Republican River, northwest of Fort Riley (Coll. Acad. Nat. Sci. Phila.); Ellis (Coll. Peabody Acad. Sci.). Missouri: St. Louis (Coll. P. R. Uhler); Osage River; Irondale. Illinois: Quincy, Adams Co.; Lawn Ridge, Marshall Co.; Decatur, Macon Co.; Normal, McLean Co. (S. A. Forbes); Pekin, Tazewell Co. (S. A. Forbes); Cairo, Alexander Co. (S. A. Forbes); Geneva, Kane Co. (Coll. Peabody Mus. Yale Coll.); Stillman's Creek, Marion, Ogle Co. (Coll. Bost. Soc. Nat. Hist.). Indiana: Michigan City, Lake Michigan (Acad. Nat. Sci. Phila.); Long Lake, Kendallville (W. F. Bundy); Elkhart River, Rome City (W. F. Bundy). Alabama: near Bridgeport, Jackson Co. (Coll. U. S. Nat. Mus.). Arkansas: White River, Eureka Springs, Carroll Co. (Coll. U. S. Nat. Mus.). Texas. New York: Lake George (?).

Cambarus virilis is subject to some variation in the shape of the rostrum, the punctation of the carapace, breadth of areola, etc., as Hagen pointed out in his account of this species, p. 64. Yet it is not liable to be confounded with any other species if good-sized specimens are at hand.

I have noticed in a few second-form (?) males of this species an interesting variation from the ordinary type of the first pair of abdominal appendages. In most examples these appendages are split for a considerable distance from the tip, and the two rami are drawn out to a point at the tip. In the other specimens the whole appendage is stouter, the prominences more pronounced, the extremity is split to a less distance from the tip, and the ends of the rami are blunt, almost tuberculate. The hooks on the third pair of legs are well developed, as in the first-form male. The abdominal appendage is not articulated, but this is sometimes the case in the other and commoner type of abdominal appendage of the second-form males. I have found both these forms together in collections made at several places (Lake Superior, Lake Winnipeg, etc.), and the differences in the sexual appendages are not accompanied by any that would indicate a new species.

A specimen of *C. debilis* from Baraboo River, Ironton, Wis., sent by Mr. Bundy, is the second form of the male of *C. virilis*.

Males are occasionally found with small hooks on the third segment of the second pair of legs, as well as on the third pair.

From the U. S. National Museum I have received the types of Street's *C. Couesi* and *C. virilis*. The differences between the two are very slight, and do not warrant their separation as two distinct species. Some of Hagen's types of *C. virilis* from the Red River of the North and the Saskatchewan River are of precisely the same form as Street's *C. Couesi*.

The following description of the living colors of *C. virilis* is given by Dr. Streets from the notes of Dr. Coues on the specimens collected in the Souris River, Dakota: —

"Carapace variegated with lighter and darker shades of brown: tail segment darker and more uniform brown, with large, symmetrical, dark brown spots, one on each side. Claws green, speckled with darker, with the protuberances yellow and reddish; other legs paler greenish. Below, including under side of the claws, greenish white, the claws speckled with dark spots. Antennæ rich brown."

A large female specimen in the U. S. National Museum, collected by Mr. Edward Palmer in a pond near Bridgeport, Jackson Co., Ala., appears to

belong here. The rostrum is mutilated, however, and my identification may be erroneous.

A young female from Lebanon, Tenn., in the Museum of Comparative Zoölogy, also seems to belong to this species.

A dry female in the Museum of Comparative Zoölogy is labelled "Lake George, L. Agassiz"; and there are also three dry specimens labelled "Montreal? Mr. Hunt." Considering the ease with which labels of dry specimens get misplaced, it is hardly safe to give Lake George and Montreal as localities for this species until confirmed by further exploration.

C. virilis attains a very large size. I have seen a female specimen which measured very nearly $4\frac{1}{2}$ inches in length, and Bundy records a specimen from Jefferson, Wis., $6\frac{3}{4}$ inches from tip of rostrum to tip of telson.

In specimens from Laramie the lateral spines of the rostrum are obsolescent, and the rami of the male appendages are more strongly curved than in the typical form. In these respects the specimens approach *C. immunis*. A male, form II., from Ellis, Kansas, in the Peabody Academy of Science at Salem, has the areola reduced almost to a line in the middle, and the shortness of the carapace behind the cervical groove shows another approach to *C. immunis*.

In specimens from Irondale, Mo., the cephalothorax is more cylindrical than in the type form, the areola wider in the middle (2 mm. in a specimen 68 mm. long, whereas in a specimen of the same size of the typical form it is about 1 mm.), and the tubercles on the internal border of the hand and on the movable finger are less prominent and more heavily ciliated. The sides of the rostrum are nearly parallel, with small acute lateral teeth. The carpus has the additional inferior spine as in Hagen's variety A. But I see no difference of sufficient importance to be deemed of specific value.

C. virilis and *C. immunis* are two of the Western species of crayfish esteemed as food. They are sometimes sent to the New York market from Milwaukee and other Western cities, but the species commonly found in the Eastern markets is *C. affinis*.

41. Cambarus immunis.

Plate X. figs. 6 a, 6 a (first abdominal appendages of male, form II.).

Cambarus immunis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 71, Pl. I. figs. 101, 102, Pl. III. fig. 160, Pl. VIII. fig. b, 1870. (Male, form I., and female.)
Cambarus immunis, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (After Hagen. No description.)
Cambarus immunis, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. pp. 4, 19, 1876. (Male, form II., and young.)
Cambarus immunis, Bundy, Proc. Acad. Nat. Sci. Phila., 1877, p. 171.
Cambarus signifer, Herrick, Tenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., for the Year 1881, p. 253, 1882.
Cambarus immunis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 146, 1884.

Known Localities. — New York (Coll. L. A. Lee). Indiana: White River (Coll. Bost. Soc. Nat. Hist.); Fall Creek, Indianapolis (Coll. Peabody Acad. Sci.); Long Lake, Kendallville (Bundy). Illinois: Aux Plains (Coll. U. S. Nat. Mus.); Belleville; Lawn Ridge; Normal; Oquawka (Coll. O. P. Hay). Michigan: Detroit River, Detroit. Wisconsin: Milwaukee (Coll. U. S. Nat. Mus.). Minnesota: Richfield, Hennepin Co. Iowa: West Liberty. Missouri: St. Louis (Coll. P. R. Uhler). Kansas: Leavenworth (Coll. Acad. Nat. Sci. Phila.); Ellis (Coll. C. H. Gilbert). Wyoming: near Laramie (Coll. U. S. Nat. Mus.). Alabama: Huntsville. Mexico: Orizaba (Coll. U. S. Nat. Mus.).

Var. spinirostris.

Plate I. fig. 5.

Cambarus immunis, var. *spinirostris*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 146, 1884.

Known Locality. — Obion Co., Tenn.

C. immunis is a very common species in Illinois, being especially frequent in the muddy ponds of the prairies. Mr. H. G. Hubbard has found it in muddy pools and ditches connected with the Detroit River, Michigan. According to Mr. Hubbard, it does not form burrows, but conceals itself among weeds.

The second form of the male was unknown to Hagen, and was first described by Forbes in December, 1876. The first pair of abdominal appendages are split for but a very short distance from the tip; the branches are thick, and neither of them is dilated, flattened, or channelled at the tip, as is the case in the first form. (See Pl. X. figs. 6 a, 6 a′.) The tufts of hair-like setæ on the inner side of the penultimate and antepenultimate segment of the second pair of legs, so characteristic of this species, are

much less developed in the females and second-form males than in first-form males. In some, especially young, specimens slight ante-apical teeth are present on the rostrum.

I am indebted to Mr. C. L. Herrick for three examples, two first-form males and one female, of his *C. signifer*. It does not differ specifically from Hagen's *C. immunis*. The antennal scale is a little broader than in the types from Illinois, and the anterior process of the epistoma is not so clearly truncated; the punctation of the carapace is more pronounced. These differences are no greater than we often find in the same species when specimens from widely separated localities are compared. The color, as given by Herrick, is "reddish (crimson) brown, not obviously figured; tail lighter; fin chestnut, marked with gray; chelæ bright crimson below; there are green markings on the body and legs, and some yellow below." In the female, the "abdomen is marked with chestnut bars on each segment above." "The young males have the chelæ greenish blue and mottled, while the coloration of the body is like the females." The figure of the antennal scale (fig. 7, b) in Herrick's paper is very incorrect.

The hand of this species figured by Hagen on Plate VIII. of his Monograph is not of the normal form, but belongs to the specimen from Huntsville, Ala., mentioned on page 72. Although this specimen is a first-form male, the tufts of cilia on the second pair of legs are hardly developed. The female from Beaufort, N. C., (M. C. Z., No. 3356,) doubtfully assigned to this species by Hagen, does not belong here. It is perhaps *C. Diogenes*.

I have seen a few specimens of *C. immunis* with the internal margin of the movable finger straight, without the excision at the base, but such cases are very rare.

In the typical form of *C. immunis* the margins of the rostrum are sinuate at the apex, without spines at the base of the acumen. In many of the well-grown second-form males and females from the Detroit River, small lateral spines are developed at the base of the acumen; and these specimens thus lead to a form from Obion Co., Tenn., (Coll. U. S. Nat. Mus.,) in which the lateral rostral spines are developed in all the examples examined (seven second-form males, nine females). The sides of the rostrum in some of these are nearly parallel as far as the lateral spines. Although these specimens are of moderate size, they show the marks of immaturity, the chelipeds being small, the chelæ narrow, with slender fingers. The inner finger is generally excised at the base, as in the typical form; the lateral

thoracic spine is better developed, the antennæ are longer (equal to the length of the body), and the tufts of cilia on the inner side of the second pair of legs are not developed. The anterior process of the epistoma is not notched or truncated. The male appendages and the annulus ventralis are as in the typical *C. immunis*. In the only old specimen (female, $4\frac{1}{4}$ inches long) the rostrum and epistoma are, unfortunately, mutilated, but the chelæ are broad, as in the typical form, and the second pair of legs show the ciliate tufts. I am disposed to consider the variations here as varietal rather than specific. The form may be called *Cambarus immunis*, var. *spinirostris*.

The only specimens I have seen from the State of New York are a pair, so labelled, in the collection of Prof. L. A. Lee. Two specimens in the U. S. National Museum, male, form II., and female, from Orizaba, Mexico, (Prof. Sumichrast,) do not differ to any extent from those inhabiting the United States.

42. Cambarus Mississippiensis.

Plate III. fig. 2, Plate X. figs. 4, 4, 4 a, 4 a'.

Cambarus Mississippiensis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 123, 1884.

Male, form I. — Rostrum broad, twice as long as broad, subexcavated above, smooth, foveolate at base, margins raised, converging anteriorly, sinuate at apex; acumen short, triangular, acute, no lateral teeth. Post-orbital ridges sulcate on outer side, with short, blunt anterior spines. Carapace densely punctate, sides lightly granulate, front lateral border not angulated. Cervical groove sinuate, with small lateral and branchiostegian spines. Areola linear anteriorly to the middle, with a small anterior and a larger posterior triangular field. Length of areola equal to half the distance from tip of rostrum to cervical groove. Abdomen as long as the carapace. Terminal segment of the telson shorter than the basal segment, hind border slightly concave at the centre; basal segment bispinose on each side. Anterior angle of epistoma notched. Sternum between the legs densely ciliated. Antennal scale very broad, apical spine short. Third maxillipeds hairy without and beneath. Chelæ large, punctate, smooth below, margined without; inner margin of hand short, furnished with dentiform tubercles irregularly disposed in a double series; a little distance from these is another line of smaller ciliated tubercles on the upper surface of the hand on a line with the middle of the base of the movable finger. Fingers long, gaping at base, each with

a punctate impressed line parallel with inner margin, and furnished with rounded tubercles on inner margin. Movable finger tuberculate on outer margin. Outer finger bearded below at base. Carpus broad, obliquely truncate on the external side, punctate and tuberculate above, a strong median internal spine, two small spines near on the base and one at the anterior end near the articulation; multispinous beneath, the two anterior spines the largest. Meros smooth, two ante-apical spines obliquely placed on upper margin, lower face with blunt biserial spines. Second pair of legs with long setæ near the end on inner side, not tufted as in *C. immunis*. Third pair of legs hooked. First pair of abdominal appendages long, deeply bifid, rami recurved at tip, parallel, internal ramus subcylindrical, dilated and grooved at tip, external ramus a little longer than the internal, laterally flattened, ending in a slender, sharp point.

Male, form II. — Rostrum with small lateral teeth; hand smaller, with smaller tubercles; hooks on third legs smaller; third pair of abdominal appendages stouter, cleft for only a short distance from the tip, tips blunt, no articulation at the base in the one specimen examined.

Female. — Rostrum as in the second form of the male. Hand shorter and broader, annulus ventralis with a very deeply excavated fossa.

Measurements of male, form I. — Length, 73 mm. Length of rostrum, 9 mm. Breadth of rostrum at base, 5 mm. Length of areola, 11 mm. From tip of rostrum to cervical groove, 25 mm. Length of chela, 35 mm. Breadth of chela, 14 mm. Length of inner finger, 24 mm. Length of internal margin of hand, 11 mm.

Five specimens, one male, form I., one male, form II., and three females, were collected by Prof. O. P. Hay in Eastern Mississippi. Two of them are labelled "Macon, Miss."

Differs from *C. immunis* in its linear areola, flatter rostrum, differently shaped chela, and male appendages, the rami of which are longer and less strongly recurved. *C. Palmeri* differs from it in its quadrangular rostrum, which has a longer acumen and more prominent lateral spines, narrower and long-spined antennal scale, and longer areola; the rami of the male appendages (form II.) are a little longer and more widely separated. *C. Alabamensis* differs by its wide areola, toothed and carinated rostrum, etc.; *C. compressus*, by its laterally compressed carapace, wide areola, narrow carinated rostrum, etc.

43. Cambarus Palmeri.

Plate III, fig. 6, Plate X. figs. 5 a, 5 a.

Cambarus Palmeri, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 124, 1884.

Male, form II. — Rostrum broad, subexcavated, margins nearly parallel from base to lateral spines, which are small and sharp; acumen long. Post-orbital ridge with sharp anterior spine. Carapace smooth and punctate above, granulate on sides, lateral spine of moderate size, anterior lateral border notched just below the sub-orbital angle, which is not prominent. Areola linear for a short distance anterior to the centre, with a small anterior and a larger posterior triangular field. The length of the areola is one half the distance from cervical groove to tip of rostrum. Abdomen as long as the cephalothorax. Proximal segment of telson bispinose on each side. Antennæ nearly as long as the body. Lamina a trifle longer than rostrum, broad, greatest width at the middle, thence tapering to the long spine at apex. Third maxillipeds hairy within and below. Anterior process of epistoma truncate at apex. Chela broad, depressed, smooth and punctate below, ciliate-punctate above, margined on the outer edge. Inner margin of hand short, with a double row of small ciliated tubercles. Fingers of moderate length, straight, corneous and incurved at tip, costate, punctate, and ciliate above. Movable finger with outer edge furnished with a double row of ciliated tubercles on basal half. Outer finger hairy below at base of inner side. Carpus tuberculate above, with a strong and acute internal median spine, and a minute one at the base; smooth below, with two prominent anterior spines. Third pair of legs hooked. First pair of abdominal appendages articulated near the base, long, stout, strongly curved, bifid for a short distance from tip, rami divergent, outer one the longer.

Female. — Annulus ventralis triangular, rounded anteriorly, posterior wall with a longitudinal sigmoid fissure. Sternum between fourth pair of legs smooth.

Length, 61 mm. Antennæ, 52 mm.

Twenty-five specimens of this species were collected for the U. S. National Museum by Mr. Edward Palmer, in a brook running into the eastern side of Red Foot Lake, near Idlewild Hotel, Obion Co., Tenn., May 30, 1882. The lot contains males of the second form and females. The rostrum, chelæ, and antennal scale are similar to those of *C. virilis*. It differs from that

species in its linear shorter areola and male appendages, which are more strongly curved, and formed more on the pattern of the same parts in *C. immunis*. In the latter species, however, these appendages are still more strongly curved, the areola is not linear in any part, the rostrum is more deeply excavated, longer, and (usually) toothless, the antennal scale is subtruncate at the end, and the hand different. Its closest relative is *C. Mississippiensis*. See description of that species, page 101.

Some of the specimens still show spots of dark color (purplish) on the chelæ, carpus, and branchial regions of the carapace. In a few specimens there is a very faint indication of a median carina on the rostrum.

44. Cambarus Alabamensis.

Plate IV. fig. 4, Plate X. figs. 3, 3, 3 a, 3 a'.

Cambarus Alabamensis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 125, 1884.

Male, form I. — Rostrum broad, punctate, subexcavated above at base, with a broad, rounded, slightly elevated median carina near the tip; sides subparallel, punctate, ciliate; acumen long, triangular, marginal spines slightly developed. Anterior spine of post-orbital ridge hardly developed. Carapace smooth, punctate, cervical groove sinuate, with minute lateral and branchiostegal spines; anterior margin notched at base of antennæ; areola wide, short (less than half as long as the distance from cervical groove to the lateral rostral spines), thickly punctate. Abdomen longer than the cephalothorax by the length of the terminal segment of telson. Telson rounded behind, basal segment bispinous Epistoma triangular. Antennæ nearly as long as the body, slender; scale moderately broad, broadest in middle, thence tapering to the apical spine. Third maxillipeds hairy within and below. Chelipeds of moderate length, strong. Chela broad, thick; hand punctate, inner margin of moderate length, scarcely serrate; fingers of moderate length, costate, ciliate-punctate, usually meeting only through their distal third. Immovable finger heavily bearded at base within, both above and below. Carpus smooth, punctate above; on the internal border there is a strong median spine; in front of this, near the articulation, is a minute spine, and behind it are one or two faint ones near the base; below, the carpus has a single small spine near the external articular point of the hand. Meros smooth, punctate, with two obliquely disposed spines near the anterior end of superior border; of the biserial spines beneath, only the distal one or two

of the outer row are developed. Third pair of legs hooked at base. First pair of abdominal appendages long, deeply bifid, rami slender, recurved, parallel, inner ramus spoon-shaped at tip, outer ramus a little longer than the inner, compressed laterally, tapering to a fine point at tip.

Male, form II. — Lateral rostral spines a little more prominent, hand smaller, hooks on third legs less strongly developed, first abdominal appendages thicker, bifid for only a short distance from the tip, rami laterally compressed, blunt-pointed.

Female — Rostrum as in the second form of the male, hand shorter and wider. Annulus ventralis with well-marked transverse fossa.

Measurements of a male, form I. — Length, 55 mm. Carapace, 25 mm. Abdomen, 30 mm. Length of antennæ, 50 mm. Length of areola, 7 mm. Breadth of areola, 2.5 mm. Length of chela, 21 mm. Breadth of chela, 9 mm. Length of movable finger, 12.5 mm.

A female of the same size has the areola 3 mm. in width, 7 mm. in length.

Forty specimens, including both forms of the male and the female, were collected by C. L. Herrick in Second Creek, Waterloo, Lauderdale Co., Ala., for the U. S. National Museum. The male appendages are very like those of *C. Mississippiensis*, the rami being longer and less strongly recurved than in *C. immunis*. It is at once distinguished by its broad and short areola from the other species in which the first abdominal appendages are formed after the pattern of those of *C. immunis*. The section of the carapace behind the cervical groove is very short in this species, and the dense beard at base of the external finger is very characteristic. In *C. compressus* the areola, although broad, is long, and the strong lateral compression of the body, different form of the chela, etc., distinguish it from this species at a glance.

45. Cambarus compressus.

Plate V, fig. 6, Plate X, figs. 2, 2′, 2 a, 2 a′.

Cambarus compressus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 127, 1884.

Male, form I. — Rostrum narrow, excavated, curved downwards, with a longitudinal median carina; margins thickened, converging, with a line of ciliated dots; acumen long, triangular, with acute lateral spines at base which are obsolescent in the largest specimens. Cephalothorax strongly compressed laterally. Post-orbital ridges armed with acute anterior spines.

Carapace punctate on both the back and sides; on the gastric region the punctation is very coarse, assuming the form of reticulation; cervical groove sinuate; no lateral or branchiostegian spines; anterior lateral margins notched behind the antennæ; areola broad, heavily punctated. Abdomen about the length of the thorax. Telson long, proximal segment bispinose on each side. Antennæ slender, shorter than the body by the length of the telson. Antennal scale of moderate width, terminal spine very long, reaching beyond the tip of the rostrum. Epistoma triangular. External maxillipeds hairy within and below. Chelipeds short, stout; chelæ very large, broad, non-tuberculate, hand convex above and below, punctate, internal margin entire; fingers short, thick, with lines of ciliated dots. Carpus punctate above, with one internal median spine. Upper border of meros with one or two ante-apical spines; the biserial spines below are not developed, except the distal one of each row, and even these are minute. Third segment of third pair of legs hooked. First pair of abdominal appendages reach the base of the second pair of legs. They are deeply bifid, the rami recurved; the outer ramus is aciculate, the inner is enlarged at base and at tip, and the tip is furthermore grooved in front and rounded off at the end.

Male, form II. — Hand smaller, fingers gaping at base, external finger ciliated at base within, hook on third segment of third legs very small; first pair of abdominal appendages articulated near the base, thick, inner and outer parts separated for only a very small distance from apex, compressed from side to side, tips a little recurved, blunt-pointed.

Female. — Chelæ somewhat smaller than in the first form of the male, fingers less widely separated at base, external finger ciliated at base within. Anterior border of annulus ventralis nearly obliterated in the median line, lateral borders raised into prominent tubercles, transverse fossa wide.

Length of body (male, form I.), 45 mm. Length of carapace, 22.5 mm. Length of areola, 8 mm. Breadth of areola, 2 mm.

In the largest specimen seen, the dimensions of which are given above, the lateral spines of the rostrum are obsolete, the margins simply notched at base of the acumen; in the other specimens the lateral rostral spines, though small, are evident; the antennæ in the larger specimens are shorter in proportion to the length of the body.

Thirty-nine specimens (eighteen males, form I., two males, form II., and nineteen females) were collected by C. L. Herrick, for the U. S. National Museum, in Second Creek, Waterloo, and in Cypress Creek, Lauderdale Co., Ala., October, 1882.

A small species, with first abdominal appendages of the male similar to those of *C. immunis*. It is readily distinguished from all the other species with similar male appendages by the lateral compression of the cephalothorax, form of the chela, etc.

46. Cambarus medius.

Plate III. fig. 4, Plate IX. figs. 4, 4′.

Cambarus medius, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 121, 1884.

Male, form I. — Rostrum of moderate length, excavated, slightly carinated at the tip; margins thickened, converging, sinuated near the tip to form the short triangular acumen; no lateral spines. Post-orbital ridges depressed, sulcated on external face, subacute anteriorly. Carapace subcylindrical, somewhat flattened above, punctate, granulated on the sides; cervical groove sinuate, no lateral or branchiostegian spine; sub-orbital angle rounded; areola long (much more than half as long as the distance from the cervical groove to the tip of the rostrum), of moderate width, punctate, widening posteriorly. Abdomen as long as the cephalothorax; telson rounded behind, basal segment bispinous on each side of the posterior border. Basal segment of antennule with an interior median spine. Second and third segments of antennæ not spiniferous (flagellum of antennæ broken off in the specimen examined, probably much shorter than the body). Antennal scale short, of moderate width, terminating in a short, acute spine. Anterior process of epistoma triangular, apex pointed, sides convex. Third maxillipeds bearded within. Chelipeds of moderate length, stout; chela broad, inflated, coarsely punctate above and below, external margin rounded; internal margin of hand with a double row of obsolescent tubercles; fingers stout, gaping at base, costate, heavily dotted-lined, internal margins furnished with rounded tubercles. Carpus sparsely punctate, armed with a moderate median and a smaller basal internal spine; below, there are no spines developed. Meros furnished with two nearly obsolete obliquely placed tubercles near the distal extremity of superior border, and with a double row of tubercles below. Second pair of legs provided with long cilia towards their distal extremity. Third segment of third pair of legs hooked. First pair of abdominal legs long (reaching to base of chelipeds), deeply bifid, rami slender, straight, the outer one a little recurved at the tip, aciculate, the inner one slightly dilated near the tip, blunt pointed; a projecting angle or shoulder at base of rami on anterior margin.

Female. — Hand small, fingers not gaping, ciliated within; sternum between fourth pair of legs plane; annulus ventralis bilaterally symmetrical, anterior border bituberculate, posterior border unituberculate, transverse fossa deep, recurved at each end.

Measurements of male, form I. — Length of body, 49 mm. Length of carapace, 25 mm. Length of rostrum, 6 mm. Length from end of rostrum to cervical groove, 15.5 mm. Length from cervical groove to hind border of carapace, 9.5 mm. Width of areola, 2 mm. Length of abdomen, 25 mm. Length of chela, 23.5 mm. Length of internal margin of hand, 9.5 mm. Breadth of chela, 11.5 mm. Length of movable finger, 14 mm.

Two specimens, first form of male and female, in the Museum of Comparative Zoölogy, from Irondale, Mo.

This species has the general form of body, rostrum, and chelæ of the *C. Bartonii* group, together with the male abdominal appendages of the *C. affinis* group. These appendages have a projecting shoulder at the base of the rami, on the anterior edge, as in *C. rusticus*, *C. Putnami*, etc. *C. immunis* and *C. Mississippiensis*, belonging to the *C. affinis* group, also have the rostrum devoid of lateral spines, but in general habit of body they do not resemble *C. Bartonii* and its allies, as is the case with the present species.

47. Cambarus rusticus.

Plate IX. figs. 8, 8, 8 a, 8 a (first abdominal appendages of male).

Cambarus rusticus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 88, 1852.
Cambarus rusticus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 71, Pl. I. figs. 80–83, Pl. III. fig. 161, 1870.
Cambarus placidus, Hagen, op. cit., p. 65, Pl. I. figs. 76-79, Pl. III. fig. 158, 1870.
Cambarus juvenilis, Hagen, op. cit. p. 66, Pl. I. figs. 29–33, Pl. III. fig. 157, 1870.
Cambarus rusticus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (After Hagen. No description.)
Cambarus placidus, Smith, op. cit., p. 638, 1874. (After Hagen. No description.)
Cambarus juvenilis, Smith, op. cit., p. 38, 1874. (After Hagen. No description.)
Cambarus Wisconsinensis, Bundy, Bull Ill. Mus. Nat Hist., No. I. p. 4, 1876. — Trans. Wis. Acad. Sci., V. 181, 1882. — Geol Wis., Surv. 1873–1879, I. 402, 1883.
Cambarus placidus, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. pp. 4, 19, 1876. (After Hagen.)
Cambarus Wisconsinensis, Forbes, op. cit., p. 19. (After Bundy.)
Cambarus rusticus, Bundy, Trans. Wis. Acad. Sci., V. 181, 1882. — Geol. Wis., Surv. 1873–1879, I. 402, 1883. (Not described.)
Cambarus placidus, Bundy, Trans. Wis. Acad. Sci., V. 181, 1882. (Not described.)
Cambarus rusticus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 148, 1884.

Male, form I. — Rostrum long, narrow, concave on the sides, excavated, margins thickened, dotted-lined, divergent at the base; acumen of moderate

length, triangular, with acute, upturned, brown, horny terminal spine; marginal spines short, upturned, fusco-corneous. Carapace flattened above, punctate, lightly granulate on the sides, lateral spine small, often obsolete, branchiostegian spine obsolete; post-orbital ridges terminating anteriorly in a very short spine, which is sometimes obsolete in large specimens; antero-lateral border very slightly angulated behind the antennæ; areola equal in length to the distance from the cervical groove to the base of the rostrum, narrow, irregularly punctate, sides subparallel for the greater part of its length, divergent at the fore and hind ends. Abdomen a little shorter than the cephalothorax; posterior border of telson rounded, posterior margin of basal segment bispinose on each side. Basal segment of antennule armed with an interior spine near the apex of lower side. Antennæ about as long as the body, spine on external margin of second segment small or obsolete; scale broad, a trifle longer than the rostrum, widest beyond the middle, thence tapering to the short, acute, horny-tipped, external apical spine. Third maxillipeds hairy within, nearly naked below. Anterior process of epistoma triangular, antero-lateral borders convex, lateral angles prominent, apex usually blunt. Chela large, punctate; internal border of hand furnished with a double row of low depressed tubercles; fingers ornamented with lines of dots, of moderate length (the movable finger not much more than twice the length of internal margin of the hand); fingers gaping at the base, not bearded, movable finger incurved, external margin concave, with obsolescent tuberculation like that on the inner margin of the hand; external finger incurved, external margin convex; inner margins of both fingers furnished with rounded tubercles. Carpus broad, coarsely punctate above, internal median spine small, in some examples obsolescent, inferior median and external spines small or obsolete; meros smooth on the external face, with two small, obliquely placed superior sub-apical spines, one or both of which may be obsolete, inferior biserial spines usually but slightly developed, except the apical one of each row. Third segment of third pair of legs hooked. First pair of abdominal appendages, when turned forward, reach the base of second pair of legs; they are deeply bifid, the rami slender, styliform, shorter than the proximal undivided part; outer ramus straight, or arcuate (the concave side being posterior), subulate; inner ramus a little shorter than outer, straight or arcuate, a little incurved at the apex, tip aciculate, or in old specimens dilated; a projecting angle or shoulder on the anterior margin at base of the rami.

Male, form II. — Hooks of third pair of legs smaller; first pair of abdominal appendages thicker, bifid for but a short distance from the tip, rami stout, the outer one the longer, the inner one slightly incurved, swollen at tip, blunt pointed; very slight trace, or none, of projecting angle on anterior margin at base of the rami.

Female. — Sternum between the fourth pair of legs smooth; anterior wall of annulus ventralis largely developed, bituberculate, fossa triangular, posterior wall with a median, backward-projecting tubercle divided by a longitudinal narrow fissure.

Length of a male, form II., 73 mm. Length of carapace, 36.5 mm. Length of abdomen, 36.5 mm. Length of rostrum, 8.5 mm. From tip of rostrum to cervical groove, 22.5 mm. From cervical groove to hind margin of carapace, 14 mm. Width of areola, 1.5 mm.

Known Localities. — Pennsylvania: Pittsburg (Coll. Acad. Nat. Sci. Phila.); Philadelphia Co. [?] (Coll. Acad. Nat. Sci. Phila.). Ohio: Kelley's Island, Lake Erie (Peabody Acad. Sci.); Miami River, Dayton (Coll. Acad. Nat. Sci. Phila.); Yellow Springs; Cincinnati, Ohio River. Indiana: Madison, Ohio River (Coll. O. P. Hay); White River (Coll. Bost. Soc. Nat. Hist.); Indianapolis (Coll. Peabody Acad. Sci.). Illinois: Quincy; Normal (W. F. Bundy). Kentucky: Little Hickman, Kentucky River; Perryville, Boyle Co.; Salt River. Tennessee: Cumberland Gap; Lebanon. Lake Superior. Wisconsin: Racine; Beloit (W. F. Bundy); Ironton (W. F. Bundy); Fox River (W. F. Bundy [*C. placidus*]). Iowa: Lizard Creek, Fort Dodge. Missouri: Osage River. Arkansas: White River, Eureka Springs, Carroll Co. (Coll. U. S. Nat. Mus.). Texas.

The above description is drawn up from Hagen's types of *C. rusticus* from Cincinnati, Ohio (M. C. Z., No. 285), and from specimens of the same form from Yellow Springs, Ohio (M. C. Z., No. 3427). Hagen's type from Lake Superior (M. C. Z., No. 187) differs in having very long, straight fingers, not tuberculate on their inner margins, like *C. placidus* Hag.

In the larger males, form I., from Yellow Springs, the rami of the first abdominal appendages are curved forwards a little at the base, and then recurved toward the tip, forming an arc; the tip of the inner rami is considerably dilated. In very young specimens of both sexes (20 mm. long, or thereabouts) there is a dense beard on the interior margin of the carpus and meros of the chelipeds, as well as on the inner side of the external finger near the base. In some specimens the fingers are long and straight.

Girard's description of *C. rusticus* is as follows: —

"Rostrum narrower than in both *C. affinis* and *C. Pealei*, and, besides, concave on the sides. Terminal point shorter than either of the preceding species [*C. pellucidus*, *affinis*, *Oregonus*, and *Pealei*]; anterior pair of abdominal legs (in the male) elongated, slender, with their tip curved inwards, whilst the same tips are straight in *C. affinis*, and twisted in *C. pellucidus*. The dorsal area is broader than in *C. Pealei*.

"Locality. — The Ohio, at Cincinnati."

This description does not fit very well, but Dr. Hagen examined one of Girard's types and ascertained its identity.

Closely related to the above described form are Hagen's *C. placidus* and *C. juvenilis*. I find so many specimens among the material at my disposal which combine characters of these three, that I am led to consider them all as varieties or forms of *C. rusticus*.

In the type (male, form 1.) of *C. placidus*, from Quincy, Ill. (M. C. Z., No. 296), the rostrum is longer and narrower than in the typical *C. rusticus*, with longer acumen and lateral spines; the hands have long, straight, non-tuberculate fingers, like the *C. rusticus* from Lake Superior mentioned above; the rami of the first pair of abdominal appendages are a little recurved, and want the projecting shoulder at the base of the rami on the anterior border; the antennal scale is subtruncate, with longer apical spine. The types from Lebanon, Tenn. (M. C. Z., No. 289), are second-form males and females. They differ from the Quincy specimen in having a well-developed internal median spine on the carpus, and an acute though small lateral spine on the carapace; in some of these specimens the rostrum is slightly carinated near the tip; the external ramus of the first abdominal appendage, instead of being straight, as in the typical *C. rusticus*, is a little recurved at the tip. Of the types from Texas (M. C. Z., No. 170) there are now five in the Museum collection, four males of the first form, one male of the second form. In three of the first forms a projecting shoulder is prominently developed on the anterior border of the first pair of abdominal appendages, as in *C. rusticus* and *C. juvenilis*; in the fourth specimen it is also present, but less marked. Two or three of these examples further agree with the typical *C. rusticus* in the form of the chela. The internal median carpal spine is strongly developed, the lateral spine of the carapace small and acute, the inner row of inferior spines of the meros well pronounced. The first pair of abdominal appendages in all the first-form male types of *C. placidus* are a little longer than in *C. rusticus*.

The types of *C. juvenilis* from Little Hickman, Ky. (M. C. Z., Nos. 213, 3347) differ from the types of *C. rusticus* in the following respects. The first pair of abdominal appendages are longer, reaching forwards as far as the base of the chelipeds when the abdomen is flexed; the rami are slenderer, longer, and set at a slight angle with the basal part of the appendage; the inner ramus is straight, parallel with the outer ramus (not twisted), pointed at the tip, not dilated. The margins of the rostrum are more thickened. The punctation of the carapace is finer. The areola is narrower, the narrowest part being in front of the centre, thence widening posteriorly; it follows that the sides of the areola are not parallel for any distance, whereas in *C. rusticus* the sides of the areola, after converging to the posterior end of the anterior triangular field, run nearly parallel to one another for some distance, diverging towards the posterior end of the carapace to form the hinder triangular areolar field. The hand is short, with long fingers which meet throughout their entire length; the external finger is barbate within at base. In the male of the second form the tip of the outer ramus of the first abdominal appendages is slightly recurved.

There is, however, some variation among these types. In one male of the first form the fingers are of moderate length, slightly gaping at the base, the inner carpal spine small but acute; the areola is of the form seen in *C. rusticus*.

Two female specimens from Cumberland Gap, Ky. (M. C. Z., No. 3580) agree with the types of *C. juvenilis* from Little Hickman.

Hagen's type of *C. juvenilis* from the Osage River (M. C. Z., No. 271) differs from the Kentucky types, and agrees with the specimens from the Osage River (M. C. Z., No. 3446) mentioned farther on.

Among specimens received from Perryville, Ky. (M. C. Z., Nos. 3442, 3443) and Salt River, Ky. (M. C. Z., No. 3578), which agree in most respects with Hagen's types of *C. rusticus*, many have an inflated hand, with very convex external border and rather short fingers. The carapace is flattened on the back. In many respects these specimens resemble *C. juvenilis*; and if *C. juvenilis* and *C. rusticus* be separated as two distinct species, it is hard to say to which species these specimens should be assigned.

Specimens from Cumberland Gap, Ky., males of the first form (M. C. Z., No. 3444), have the rami of the first pair of abdominal appendages long and slender, as in *C. juvenilis*; when the abdomen is flexed, these appendages reach forward to the base of the chelipeds. The internal median

and the inferior median anterior spines of the carpus are well developed; of the spines of the meros, the superior apical and the external row of the inferior biserial ones are developed; only one or two of the distal ones of the inner row are present. In one specimen the fingers are much elongated. There is a dark ring around the fingers near the tip. The carapace is flattened above, densely and coarsely punctate, lateral spines small, acute; areola as wide as in the typical *C. rusticus*, and of a similar form. A closely similar form comes from Lizard Creek, Fort Dodge, Iowa (M. C. Z., No. 3554).

In small specimens, 52 mm. long, males of the second form and females, from Southern Indiana (M. C. Z., No. 3553), the lateral spine of the carapace, the anterior spine of the post-orbital ridge, and the spine of the carpus and meros, are acute and well formed, though small. The rostrum is excavated, and thickened on the margins, as in the typical *C. rusticus*.

A type, male form II., of *C. Wisconsinensis* Bundy, from Racine, Wis., received from Dr. Bundy (M. C. Z., No. 3448), agrees in most particulars with *C. placidus* Hagen. The rostrum is shorter, and the internal part of the first abdominal appendages is swollen near the tip, as in Hagen's *C. rusticus*. The anterior process of the epistoma is not truncate or emarginate. The interior median and inferior median carpal spines are well developed.

In the same jar with *C. virilis* from the Osage River (M. C. Z., No. 169) I find many small specimens, males of the second form and females, which agree very closely with the types of *C. placidus* from Lebanon, Tenn., and from Texas. With these goes a single first-form male from the same locality (Osage River), determined by Hagen as *C. juvenilis* (M. C. Z., No. 271). The largest of these specimens (a female) is 71 mm. long. The rostrum and antennal scale are as in *C. placidus*, the fingers of moderate length, the internal median carpal spine well developed, the inferior median carpal spine small and acute (in the first-form male obsolescent), the areola narrow. The first abdominal appendages of the first form of the male have a prominent angle on the anterior border, the inner ramus is straight, dilated at the tip, the outer ramus is a little recurved; in the second form of the male the inner ramus is straight, the outer slightly recurved at the tip. The inner side of the base of the external finger is bearded in the female and second-form male, naked in the first-form male. Differs from *C. Putnami* in having a narrower, more excavated rostrum, narrower areola, and shorter male appendages.

In the collections of the Peabody Academy of Science, the Boston Society of Natural History, and Bowdoin College, there are many young speci-

mens, second-form males and females, from Bradford, Ind., collected by A. S. Packard, Jr., labelled (apparently in Dr. Packard's hand) "*Cambarus spinosus* Bundy," in one case "*Cambarus spinosus* Bundy, *fide* Bundy." They are certainly not *C. spinosus*, which is a Southern species with a short areola. I think they are young *C. rusticus*, some of them possibly *C. Putnami*. The areola is rather broad for *C. rusticus*, and the male appendages are rather short for *C. Putnami*. In some of these specimens the rostrum is broad and nearly plane (in this resembling *C. obscurus*), and even a little carinated near the tip. The tips of the fingers are orange-color preceded by a dark ring.

All the forms mentioned above agree in having an excavated rostrum with thickened margins, a long and narrow areola, the first pair of abdominal appendages of the first-form male furnished with a projecting angle on the anterior margin at base of rami (except in the *C. placidus* from Quincy, Ill., in which this angle is obsolete), the rami long and straight or the outer one somewhat recurved. The chelæ have a double row of low, inconspicuous tubercles on their inner margin. They vary somewhat in the width of the rostrum and areola, in the development of the spines of the rostrum, carapace, carpus, and meros, in the length and curve of the fingers, and in the length of the rami of the first abdominal appendages. After a careful comparison of all the specimens before me, I am inclined to unite them all as forms of *C. rusticus*.

In the collection of the Academy of Natural Sciences of Philadelphia are five dry specimens of this species (Nos. 126[a], 126[c]), which, according to the labels, came from the State of Pennsylvania. Two of these are labelled by Dr. Hagen "*C. placidus*." Three (126[a], 126[c]. Philadelphia Co. and Pittsburg) are in the same box together, labelled "*A. Bartonii*" by Gibbes, "*C. affinis*" by Hagen; and on pages 62 and 78 of his Monograph Dr. Hagen says that the types of *A. Bartonii* Gibbes in the Philadelphia Academy are *C. affinis* Say. When I examined the Philadelphia collection in December, 1882, they seemed to me surely *C. placidus* Hagen. No. 126[b] in the same collection, labelled "*C. affinis* Say (*C. Bartonii* Gibbes)," is the true *C. Bartonii*, from Delaware. There is little chance that transposition of labels has taken place, as the number is pasted upon the specimens, and Gibbes's label and the original locality label bear the same number.

48. Cambarus spinosus.

Plate IX. figs. 7, 7′, 7 a, 7 a′ (first abdominal appendages of male).

Cambarus spinosus, Bundy, Proc. Acad. Nat. Sci. Phila., 1877, p. 173.
Cambarus spinosus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 148, 1884.

Male, form II. — Rostrum broad, excavated, the raised margins parallel and continued back on the carapace between the post-orbital ridges, an impressed ciliated line on each margin; acumen long, acute, with well-developed lateral teeth at base. Post-orbital ridges sulcate without, with short anterior spines. Carapace ovoid, smooth and punctate above, lightly granulated and ciliated on the sides, lateral spines single, long, acute; cervical groove not sinuous; small branchiostegian spines; front border of carapace a little angulated behind the antennæ; areola moderately wide, of equal width before and behind, punctate, equal in length to half the distance from cervical groove to lateral rostral spines. Abdomen equal to the cephalothorax in length, mostly smooth, proximal segment of telson bispinose on each side. Epistoma wide, emarginate in front. Antennæ long (as long as the body or longer); scale as long as the rostrum, narrow, widest in the middle, thence tapering gradually to the long, sharp, apical tooth; external border inflated, turned outward at the distal end. Third pair of maxillipeds hairy without, naked below. Chela of moderate size, punctate above, smooth below, a double row of ciliated tubercles on the inner border of the hand; fingers of moderate length, slightly gaping at base, costate and ciliate-punctate, toothed and ciliate on inner border; outer margin of movable finger with two or three rows of tubercles. Carpus tuberculate above, internal border with a large, curved, sharp median spine, and a small anterior and posterior spine; below there is a large median spine on anterior margin, and a smaller one at the point of articulation with the hand. Meros with two obliquely disposed spines near the distal end of superior border; the outer row of the biserial spines beneath consists of the two distal spines alone. Third pair of legs hooked. Anterior pair of abdominal appendages very long, reaching forward to the base of the large claws, deeply bifid, rami slender, blunt-pointed, outer ramus longer than the inner, a little recurved at the tip.

Male, form I. — According to Bundy, the hooks on the third legs are larger; first pair of abdominal appendages "strongly bifid, tips of equal length, very slender, straight, separating at node; anterior margin with a

tooth or projecting angle about midway from base to extremities; apical forming a very obtuse angle with basal half."

Female. — Fingers shorter than in the male; annulus ventralis with a large tubercle on the posterior margin divided in the middle by a longitudinal sinuous line, anterior border bituberculate, fossa deep, transverse.

Measurements of a male, form II. — Length, 70 mm. Cephalothorax, 35 mm. Abdomen, 35 mm. From tip of rostrum to cervical groove, 24 mm. From cervical groove to posterior border of telson, 10 mm. Length of rostrum, 11 mm. Width of rostrum, 4.5 mm. Length of acumen of rostrum, 5 mm.

Known Localities. — South Carolina: Saluda River (Coll. Butler Univ.). Georgia: neighborhood of Rome (Etowah, Oostenaula, and Coosa Rivers). Tennessee River near border of Georgia. Alabama: Cypress Creek, Lauderdale Co.

The specimens described by Bundy were collected in the neighborhood of Rome, Ga., by Prof. D. S. Jordan. Some of these specimens have been communicated to me by Prof. O. P. Hay, of Butler University, Irvington, Ind., and Mr. P. R. Uhler, of Baltimore, Md. They embrace males of the second form, females, and young. According to Bundy, only one out of the nineteen specimens examined by him was a male of the first form.

In general appearance this species resembles *C. affinis*, but differs in being smoother, in the shortness of the carapace behind the cervical groove, the single lateral spine, the absence of spines on the hepatic region, emarginate epistoma, longer antennæ, and in the form of the male appendages, which resemble those of *C. rusticus* and *C. obscurus*. In these, however, the male appendages are shorter, and the rami are shorter relatively to the length of the whole appendage.

The female specimen from the Tennessee River near the borders of Georgia, mentioned by Hagen under *C. extraneus* as resembling *C. affinis*, belongs to this species. Jordan also found *C. spinosus* in company with *C. extraneus* in the rivers explored by him in the neighborhood of Rome, Georgia.

In the collection of Butler University is a single female *C. spinosus*, collected by Jordan in the Saluda River, South Carolina. In this specimen the posterior section of the carapace is a little longer than in the Georgian types, the distance from the cervical groove to the posterior border of the carapace being equal to half the distance from the groove to the middle of the

acumen of the rostrum, and the anterior process of the epistoma is longer and not emarginate.

Before this species was well known, the female might easily have been confounded with *C. affinis*. I suspect that the female specimen from Greenville, South Carolina, in the Berlin Museum, referred to *C. affinis* by Erichson, belongs here.

The Saluda River specimen is the largest seen by me. It measures $3\frac{1}{2}$ inches in length. Bundy gives the length of the largest examined by him as $3\frac{3}{4}$ inches.

Specimens collected for the U. S. National Museum in Lauderdale Co., Alabama, by C. L. Herrick, agree in most respects with the specimens from Georgia, but differ as follows. The lateral margins of the rostrum, instead of being very nearly parallel from the base to the lateral spines, converge very perceptibly from the base to midway between the base and the lateral spines; the epistoma is longer, but emarginate in full-grown specimens, like the type form; the carapace is more heavily punctate. I am inclined to regard it as a variety of *C. spinosus*.

Among these specimens from Lauderdale Co. is the first form of the male, in which the hand is broader and shorter-fingered than in the second form, and the hooks on third legs larger; the first abdominal appendages (Pl. IX. figs. 7, 7′) agree pretty well with Bundy's description of these parts in *C. spinosus*, but the outer ramus is a little longer than the inner. The shoulder at the base of the rami, on the anterior border, is very prominent; the inner ramus is thicker than the outer, lanceolate at the tip, the outer aculeate at the tip. The rami form a hardly perceptible angle with the basal part of the appendage. The coloration of these specimens agrees with Bundy's description of the color markings of *C. spinosus*. The fingers have a dark band near their tips, the tips being orange; outer margin of outer finger with a dark stripe continued on the outer margin of the hand to the carpus; two or three dark spots on the hand at the base of the movable finger. Until I have seen the first form of the male of *C. spinosus* from Georgia, I cannot be positive of its specific identity with the Alabama specimens.

49. Cambarus Putnami.

Plate V. fig. 5, Plate IX. figs. 6, 6′, 6 a, 6 a′.

Cambarus Putnami, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 131, 1884.

Male, form I. — Rostrum broad, subexcavated, margins nearly parallel, with a line of ciliated puncta; acumen long, equal in length to the width of base of rostrum, narrow, acute, with a black horny tip and lateral spines. Post-orbital ridges sulcate on external side, inflated at posterior end, armed with a sharp, horny-tipped anterior spine. Carapace long-oval, slightly flattened above, heavily punctated, sides rough with ciliated granules; cervical groove deep, lightly sinuate, broken on the sides just above the small, acute lateral spine; branchiostegian spine slightly developed; anterior lateral margins angulated, but without sub-orbital spine. Posterior segment of carapace equal in length to half the distance from tip of rostrum to cervical groove. Areola of moderate width, punctated. Abdomen as long as cephalothorax, pleura punctate, telson bispinose on each side. Anterior process of epistoma ciliated, triangular, sides convex, marginate. Basal segment of antennule armed below with an internal ante-apical spine. Antennæ slender, about as long as the body, scale as long as the rostrum, of moderate width, external border inflated, ending in a sharp spine. Third maxillipeds hairy within and below. Chelipeds stout; chela large, external margin convex; hand ciliate and punctate above and below (the dots large), swollen above, internal border of moderate length and furnished with two or three rows of depressed ciliated tubercles; fingers gaping at base, at least in large individuals, costate and punctate-lined, external margin of movable finger with depressed ciliated tubercles irregularly disposed in two rows; tips of fingers incurved, horny. Carpus smooth or faintly tuberculate above; a large, acute median internal spine, and small proximal and distal internal spines; beneath, the carpus has a very minute or no median anterior spine, a short and acute external spine. Meros with two superior obliquely placed ante-apical spines; of the ordinary biserial inferior spines only the distal one or two of the outer row are developed. Third pair of legs hooked on third segment. Thoracic sterna hairy. First pair of abdominal appendages very long, reaching the base of the chelipeds when the abdomen is flexed, tuberculated on internal border at the base, deeply bifid; rami slender, acute, forming an acute angle with the basal part, the outer slightly recurved, the

inner shorter, incurved, and a little dilated before the tip; a projecting angle or shoulder on the anterior border at base of rami.

Male, form II. — Chela smaller, fingers not gaping, hook on third segment of third pair of legs smaller; first pair of abdominal appendages split only half as far down as in the first form, rami much thicker, no projecting angle on the anterior border; these appendages are as long as in the first form, reaching forward to the base of the chelipeds; they are articulated near the base.

Female. — Chela shorter and wider, external finger bearded within at base; sternum between fourth pair of legs non-tuberculate, lightly ciliate. Annulus ventralis large, transverse fossa broad and deep, anterior border bituberculate.

Measurements of a male, form I. — Length of body, 73 mm. Length of carapace, 36 mm. From tip of rostrum to cervical groove, 24 mm. From cervical groove to hind border of carapace, 12 mm. Length of rostrum, 11 mm. Breadth of rostrum at base, 4.5 mm. Length of acumen of rostrum, 4 mm. Width of areola, 2.5 mm. Length of abdomen, 37 mm. Length of chela, 34 mm. Breadth of chela, 14 mm. Length of movable finger, 22 mm.

Known Localities. — Kentucky: Grayson Springs, Grayson Co.; Green River, near Mammoth Cave; Cumberland Gap.

M. C. Z., No. 3574 (young female), from Knoxville, Tenn., Walter Faxon, and No. 3575 (male, form II.), from Bradford, Ind., A. S. Packard, Jr., probably belong to this species, but the specimens are too young to determine with confidence.

This species resembles *C. spinosus*, from which it is easily distinguished by the length of the posterior section of the carapace, and by the length of the male appendages. From *C. affinis* it may be separated by the different form of the male appendages and female annulus ventralis, and by the single lateral spine of the carapace. I have seen males of the first form only 34 mm. in length.

50. Cambarus forceps.

Plate V. fig. 4. Plate IX. figs. 5, 5′, 5 a, 5 a′.

Cambarus forceps, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 133, 1884.

Male, form I. — Rostrum narrow, excavated, faintly carinated in the middle; margins divergent at the base, thickened, dotted-lined; acumen long

and narrow, horny-tipped; lateral spines small. Post-orbital ridges not very prominent except anteriorly, where they terminate in a spine with a corneous tip. Carapace cylindroidal, punctate above, granulated on the sides, antero-lateral margins bluntly angulated; cervical groove sinuate; small and acute lateral spine; no branchiostegian spine; areola of moderate width, punctate. Abdomen as long as the cephalothorax; telson rounded behind, bispinose on each side. Epistoma smooth, anterior process triangular, in some specimens truncate. Thoracic sterna with silky setæ at bases of the legs. Antennæ slender, as long as the body; scale a little longer than the rostrum, of moderate width, subtruncate at distal end, outer margin ending in a long, sharp, somewhat outwardly directed spine. Third pair of maxillipeds hairy within. Chelipeds short, stout; chelæ large, wide, with slender cylindrical, widely gaping fingers, which are curved outward at the base and opposable only at their tips; hand thickly punctated above and below, inner margin obscurely serrate; fingers naked at base, with parallel rows of ciliated dots; a dark band around both the inner and outer fingers a little distance from the tip. Carpus punctate above, with a strong, sharp internal median spine; below there is no anterior median spine, and only a very minute external one. Meros short; of the biserial inferior spines only the distal one in each row is usually developed to any extent; above there are commonly two obliquely placed ante-apical spines, in some specimens only one. Distal portion of the following pairs of legs furnished with long setæ, especially long on the second pair of legs. Third segment of third pair of legs hooked. First pair of abdominal appendages long, deeply bifid; rami slender, straight, parallel, the outer a little longer than the inner, and a little recurved at the tip; in some specimens the anterior border at the base of the rami has a projecting angle or shoulder, but in most specimens this is not evident.

Female. — Fingers straighter. Base of external finger has a dense beard on the inside; in a few of the specimens seen, the fingers are longer, nearly straight, their opposed margins almost meeting throughout their length. Annulus ventralis bilaterally symmetrical, anterior margin bituberculate, posterior margin unituberculate, fossa transverse.

Dimensions of a male, form I. — Length of body, 38 mm. Length of carapace, 19.5 mm. Length of abdomen, 18.5 mm. From tip of rostrum to cervical groove, 14 mm. From cervical groove to posterior border of carapace, 6 mm. Length of rostrum, 5 mm. Length of acumen of rostrum, 2 mm. Width of areola, 1 mm. Length of antenna, 36 mm.

Length of chela, 16 mm. Breadth of chela, 7.5 mm. Length of movable finger, 10.5 mm.

The largest female specimen is 60 millimeters in length.

Locality. — Cypress Creek, Lauderdale Co., Ala.

Nine specimens, four males of the first form and five females, collected by C. L. Herrick for the U. S. National Museum, October, 1882.

This is a small species with large hand, slender fingers widely separated at base and meeting only at the tips. In the female there is a heavy beard at base of external finger on the inner side.

In the summer of 1872, I collected in a brook at Knoxville, Tenn., six specimens, three second-form males and three females, which closely resemble those obtained by Mr. Herrick in Alabama, and belong, I think, to the same species. The external finger of the males is densely bearded within at the base, as in the females from Alabama; the first abdominal appendages reach forward to the base of the second pair of legs, are bifid at the tip, the internal and external parts are thick, blunt at the tip, the outer somewhat longer than the inner, and slightly recurved at the tip.

GROUP V. (Type, **C. Montezumæ.**)

Third segment of the second and third pairs of legs hooked. First pair of abdominal appendages of the male similar to those of the species included in Group IV.

51. Cambarus Montezumæ.

Plate II. fig. 6, Plate X. figs. 7, 7′, 7 a, 7 a′.

Cambarus Montezumæ, Sàussure, Rev. et Mag. de Zool., 2e Sér., IX. 102, 1857. — Mém. Soc. Phys. Hist. Nat. Genève, XIV. 459, Pl. III. fig. 22, 1858.
Cambarus Montezumæ, var. *tridens*, Von Martens, Arch. Naturgesch., XXXVIII. Jahrg., I. 130, 1872.
Cambarus Montezumæ, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 149, 1884.

Cambarus Montezumæ and *C. Shufeldtii* are small species distinguished from all the others of the genus by having hooks on the third joint of the *second and third* pairs of legs of the male. In *C. Montezumæ* the rostrum is plane or lightly concave above, with a slightly raised margin; it varies much in its shape. In the typical form, as described and figured by Saussure, its margins are subparallel from the base to near the extremity, where they con-

verge to form the short acumen, without lateral angle or spine. In other specimens there are lateral spines at the base of the acumen (var. *tridens* of Von Martens), and in an intermediate form the rostrum is simply angulated instead of spinous at the base of the acumen. The sides may be more or less convergent from the base. In specimens from Mazatlan, the rostrum, although destitute of lateral spines, differs from the typical form in being longer and more tapering. The post-orbital ridges are in some specimens unarmed at the anterior end, in others they end in a sharp spine. The fore border of the carapace is angulated under the orbit. No branchiostegian spine. Carapace smooth, punctate on the gastric region and areola. No lateral spine. Areola of moderate width. Abdomen longer than the cephalothorax, broad, especially in the female. Anterior segment of telson armed on each side with one, two, or (seldom) three spines. Antennal scale broad. Chelipeds without spines or tubercles, excepting, in some specimens, one or two spicules at distal end of superior border of the meros; hand of male long, cylindrical, inflated; fingers slender, with cutting edges smooth, meeting throughout their length. In the female the chela is shorter and broader.

In the first form of the male the third segment of the second and third pairs of legs has a sharp hook, the first abdominal appendages are of moderate length, recurved, bifid, the rami divaricate, horny-tipped, the outer one ending in a slender recurved point, and furnished with a single seta on its posterior border, the inner one laterally compressed, spoon-shaped at the end.

The second form of the male has the hooks on the second and third pairs of legs slightly developed, the first pair of abdominal appendages less deeply bifid, the tips of the rami membranous and both blunt.

Annulus ventralis of the female movable, fixed only at the posterior end, between the sterna of the penultimate and the last thoracic somites. The ventral face of the annulus is marked by a longitudinal fossa open at the posterior end.

Saussure's types of *C. Montezumæ* in the Berlin Zoölogical Museum were examined in September, 1870, by Dr. Hagen, who has kindly furnished me with the following information concerning them. The types are in alcohol, male, form I., and female. In the male (young) the rostrum is nearly rounded in front. Another jar contains male, form II., and female, also from Saussure, with tridentate rostrum. The second and third pairs of legs are hooked, as is stated by Saussure.

In Archiv für Naturgeschichte, XXXVIII., 1872, page 130, Von Martens communicates some remarks upon the form with lateral rostral spines, received by the Berlin Museum from Puebla, Mexico, together with the typical *C. Montezumæ* and *C. Aztecus*. This form he calls *Cambarus Montezumæ*, var. *tridens*. The largest part of those which I have myself seen, amounting to about seventy specimens, have the lateral spines on the rostrum, but in some specimens the spines are very small, and in others reduced to a mere angle at the base of the acumen.

Some of the female specimens collected by Prof. A. Dugès, in the collections of the U. S. National Museum, have a short, broad, and hirsute chela.

Five imperfectly preserved dry specimens in the Museum of Comparative Zoölogy come from Mazatlan. These specimens have a rather long, tapering, entire rostrum, but do not differ from *C. Montezumæ* enough to warrant separation. The sexual parts are the same as in the more eastern specimens. It appears from these specimens that the genus Cambarus extends, in Mexico, to the Pacific coast.

There are also in this Museum six specimens, two males, form I., three females, and one young male, collected by Mr. Edward Palmer near Parras, Cohahuila, Mexico, which differ from *C. Montezumæ*, var. *tridens*, in having the section of the carapace posterior to the cervical groove shorter, the areola much broader. This form, which I have named provisionally *C. Montezumæ*, var. *arcolata*, may prove to be a good species. But considering the variability of individuals of *C. Montezumæ*, and the small number of Mexican localities from which specimens have been received, I prefer to treat this form as a variety simply, the more because the sexual parts of both male and female are like those of *C. Montezumæ*. In this form, the distance from the cervical groove to the posterior margin of the carapace is half (or even less) the distance from the cervical groove to the lateral rostral spines. The areola is about half as broad as it is long. Length of body, 28 mm.

The largest specimen of *C. Montezumæ* which I have seen measures 38 mm. from tip of rostrum to end of the telson.

Known Localities. — Mexico: marshes of the Valley of Mexico (Saussure); ponds, Chapultepec; Lake Tezcoco,* near city of Mexico; Puebla (Von Martens); Lake San Roque, Trapuato (Coll. U. S. Nat. Mus.); Parras; Mazatlan.

* Lake Tezcoco is said to be salt.

52. Cambarus Shufeldtii.

Plate VII. fig. 1, Plate X. figs. 8, 8′, 8 a, 8 a.

Cambarus Shufeldtii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 134, 1884.

Male, form I. — Rostrum plane above, margins a little convergent, raised into a slight rim from the base to the lateral spines, which are prominent and acute; acumen of moderate length, acute, pubescent. Post-orbital ridges with anterior spines. Carapace smooth; a sharp spine on the cervical groove on each side; sub-orbital angle prominent, branchiostegian spine present. Areola of moderate breadth. Telson bispinous on each side. Epistoma triangular. Antennal scale broad. Hand smooth, cylindrical, inflated; fingers slender, incurved at the tips. Carpus smooth, armed with a single spine on the antero-inferior border. Meros provided with a single spine near the distal end of the superior margin, and two or three below. Third segment of second and third pairs of legs hooked. First pair of abdominal appendages straight, bifid, inner part ending in a straight, acute tip, outer part split at the tip into two straight acute points.

In the second form of the male the hooks upon the thoracic legs are very slightly developed, and the first abdominal appendages are less deeply cleft, with blunter and less finished tips. The chela is shorter.

In the female the chela is much shorter, broader, and less cylindrical, the abdomen broader. Annulus ventralis a transverse curved ridge, the hind side of the ridge concave.

Length, 19 to 27 mm.

Locality. — Near New Orleans, La.

Found with *C. Clarkii* in the collection made by Dr. R. W. Shufeldt, U. S. A., in 1883, now in the U. S. National Museum.

This is a minute species closely related to *C. Montezumæ* from Mexico. Like that species, it has the *second and third* pairs of legs hooked in the male, a condition which normally obtains in no other species known.* *C. Shufeldtii* is distinguished from *C. Montezumæ* by the presence of a lateral spine on the carapace and by the form of the male appendages. In the latter species the tips of these appendages are recurved, the inner part flattened at the end into a spoon-shaped surface. In *C. Shufeldtii* the tips of these organs are straight, and each of the three points in which they terminate is acute.

* I have seen two or three abnormal specimens of *C. virilis* and *C. propinquus* with a like disposition of hooks on the legs. The same arrangement is found in the three species of Cambaroides from the Amoor River basin and Japan.

ASTACUS.

In the genus Astacus the last thoracic somite bears a gill (pleurobranchia) on each side, the full number of gills being thirty-six (eighteen in each branchial chamber). There are besides two or three rudimentary gills on each side of the body. The hindmost podobranchia is provided with a plaited, bilobed lamina, like those in front. The arrangement of the gills is expressed in the following formula: —

Somite.	Podobranchiæ.	Arthrobranchiæ. Anterior.	Arthrobranchiæ. Posterior.	Pleurobranchiæ.	
VI.	0 (ep.)	0	0	0	= 0 (ep.)
VII.	1	1	0	0	= 2
VIII.	1	1	1	0	= 3
IX.	1	1	1	0	= 3
X.	1	1	1	0 or r	= 3 or $3+r$
XI.	1	1	1	r	= $3+r$
XII.	1	1	1	r	= $3+r$
XIII.	0	0	0	1	= 1
	6 + ep.	+ 6	+ 5	+ 1 + 2 r or 3 r	= 18 + 2 r or 3 r + ep.

The orifice of the green gland is situate on the posterior face of the tubercle. The annulus ventralis is represented by a transverse ridge behind the penultimate thoracic sternum.

The Astaci occupy three widely separated geographical areas: 1. Western North America from the Rocky Mountains to the Pacific Ocean;* 2. The western portion of the Europæo-Asiatic continent, from the Ural Mountains and the basin of the Sea of Aral to the Spanish peninsula and Ireland; 3. Eastern Asia in the Amoor River system (Transbaikailia, Territory of Amoor, and Manchooria), and in Japan. No Astaci are known from any part of Siberia between Lake Baikal and the Ural Mountains, or from any of the Siberian rivers that flow into the Arctic Ocean.†

The North American and European Astaci form a natural group (Astacus proper). In these the body is robust and ovate, the first pair of abdominal

* One species, *A. Gambelii*, has invaded the territory of the Cambari, following down the Yellowstone River to its mouth.

† That is, no species known to be indigenous. *A. leptodactylus* has been artificially introduced into the Irtish River basin.

appendages of the male are neither bifid nor toothed at the tip, and there are no hooks near the base of any of the thoracic legs.

The Astaci from Western Asia curiously simulate the Cambari of North America in the general shape of the subcylindrical body and in the form of the chelipeds. The second and third pairs of thoracic legs of the male bear hooks on the third segment similar to those of the male Cambarus, and the first pair of abdominal appendages are terminated with short teeth. The three Asiatic species, *A. Japonicus*, *Dauricus*, and *Schrenckii*, thus form a second natural group, combining some of the characters of Astacus and Cambarus. This group I have called Cambaroides.

Subgenus CAMBAROIDES.

Cephalothorax subcylindrical. Last thoracic segment bearing a pair of pleurobranchiæ. Third segment of second and third pairs of legs of the male hooked. First pair of abdominal appendages of the male terminating in short teeth or tubercles.

The three species *Astacus Japonicus*, *Dauricus*, and *Schrenckii*, from Japan and the basin of the Amoor River, widely separated from the rest of their family in geographical position, form a natural group of subgeneric value, to which I have given the name Cambaroides. In them is found a combination of characters of Astacus and Cambarus. In the general appearance of the body, with its subcylindrical cephalothorax, and in the form of the rostrum and chelipeds, these Asiatic Astacidæ strikingly recall the Cambari of North America, and their affinity is made more evident through the hooked thoracic legs and tooth-tipped sexual appendages of the male. The hooks are situate, in all these species, on the third segment of the second and third pairs of legs, as in *Cambarus Montezumæ* and *Shufeldtii*. The rostrum is devoid of lateral teeth. The carpus is armed with a strong median internal and an anterior inferior spine. The external flagellum of the antennules is serrate below, each segment being produced at its antero-inferior angle, which bears a bundle of eight or ten of Leydig's olfactory organs. These are arranged in a single group on each antennulary segment, instead of being distributed into two bundles, as in Cambarus and Astacus proper.* The front border of the carapace is strongly angulated behind the

* The same arrangement of the olfactory setæ is found in the Parastacinæ.

eyes. The areola is broad, about one half as broad as long. The telson is notched on each side, and furnished with one or two spines, but it is not divided by a transverse suture. In this respect these species resemble the Parastacinæ of the Southern hemisphere. The transverse suture of the telson is most complete in the genus Cambarus and in the European Astaci. The Astaci of Western North America occupy a middle ground in this regard, the suture being incomplete or absent.

In all the male specimens of Cambaroides that I have seen (one *A. Dauricus*, three *A. Japonicus*), the first abdominal appendages are divided into two sections by a transverse suture. The distal portion of these appendages is so closely rolled and consolidated that a mere groove remains on the inner side. The tip is truncate, and furnished with a few short blunt teeth or tubercles. I suspect the existence of two forms of the male here, as in Cambarus, for in the male specimen of *A. Dauricus* the hooks on the thoracic legs are strongly developed, and some of the teeth at the end of the first abdominal appendages are brown and horny at the tips, whilst in the three male *A. Japonicus* the hooks of the thoracic legs are weak, and the terminal teeth of the first abdominal appendages are smaller and not of a horny texture.

The second pair of abdominal appendages of the male are somewhat different from those in the genera Cambarus and Astacus proper. The terminal part of the endopodite, which retains the membranous character of the exopodite in Cambarus and Astacus proper, is here corneous, very short, and closely applied to the rolled lamella which lies on the inner side of the appendage. The rolled part assumes a somewhat triangular shape, as in Cambarus and the Astaci of Western North America.*

In the female of *A. Schrenckii* there is a transverse tubercle behind the sternum of the penultimate thoracic somite, much as in Astacus proper. In *A. Dauricus* and *A. Japonicus* this transverse tubercle or ridge is hollowed out behind, but still remains closely soldered to the sternum. The first abdominal somite of the female is devoid of appendages, as in the American species of Astacus and in the Parastacinæ.

In the number and arrangement of the gills, Cambaroides agrees with Astacus, and differs from Cambarus.

The post-orbital ridge is slightly developed in all the species. It is least prominent in *A. Japonicus*, in which even the anterior end of the ridge is

* The reader is referred to page 17 of Hagen's Monograph, and to page 146 of Huxley's "Crayfish," for a general description of these appendages in Cambarus and Astacus proper.

barely indicated as a minute tubercle. In *A. Dauricus* the post-orbital spine is more prominent; it lies very close to the margin of the carapace; the ridge continues but a very short distance backward from the spine. In *A. Schrenckii* the spine and ridge are more pronounced, but still small.

The three species may be separated by the following table: —

A. Lateral spine behind the cervical suture. Rostrum convex above . . . . . *A. Schrenckii.*
B. No lateral spine behind the cervical suture. Rostrum concave and lightly carinate above.
a. Rostrum equal in length to peduncle of antennæ. Abdominal pleura narrow, pointed. *A. Dauricus.*
b. Rostrum shorter than peduncle of antennæ. Abdominal pleura broad, rounded. . . *A. Japonicus.*

1. Astacus (Cambaroides) Japonicus.

Plate X. figs. 10, 10′ (first abdominal appendages of male).

Astacus Japonicus, De Haan, Crustacea of Siebold's Fauna Japonica, p. 164, Tab. XXXV. fig. 9, 1842.
Astacus Japonicus, Erichson, Arch. Naturgesch., XII. Jahrg., I. 94, 1846. (After De Haan.)
Astacus Japonicus? Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 364, 1874.
Astacus (*Cambaroides*) *Japonicus*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 149, 1884.

Habitat. — Japan.

Prof. C. O. Whitman, to whom the Museum of Comparative Zoölogy is indebted for four specimens of this species, informs me, that, during his residence in Japan, he could not learn of its occurrence in Niphon, the main island of the Empire, all the specimens known to him coming from the island of Yesso. Kessler's specimens came from the same locality as Prof. Whitman's, viz. Hakodadi, Yesso.

In the four specimens received from Prof. Whitman, the posterior margin of the telson is rounded, and shows no trace of the deep median notch described and figured by De Haan. In this respect, these examples agree with those described by Kessler. Individuals with similarly notched telson are found in some other species, e. g. *A. Gambelii*, although in these the emargination is less pronounced.

The rostrum terminates in three minute horny points. The branchial formula is the same as in *Astacus fluviatilis*, there being one pleurobranchia (on each side) on the last thoracic somite, and one rudimentary pleurobranchia, in the shape of a simple filament, on each of the three antecedent somites.

The arrangement of the gills is shown in the following table: —

Somite.	Podobranchiæ.	Arthrobranchiæ. Anterior.	Arthrobranchiæ. Posterior.	Pleurobranchiæ.	
VI.	0 (ep.) *	0	0	0	= 0 (ep.)
VII.	1	1	0	0	= 2
VIII.	1	1	1	0	= 3
IX.	1	1	1	0	= 3
X.	1	1	1	r	= 3 + r
XI.	1	1	1	r	= 3 + r
XII.	1	1	1	r	= 3 + r
XIII.	0	0	0	1	= 1
	6 + ep.	+ 6	+ 5	+ 1 + 3 r	= 18 + 3 r + ep.

The structure of the gills and coxopoditic setæ is the same as in the Astaci proper.

2. Astacus (Cambaroides) Dauricus.

Plate X. figs. 9, 9′ (first abdominal appendages of male).

Astacus Dauuricus, Pallas, Spicilegia Zoologica, Fasc. IX. p. 81, 1772.
Cancer Dauuricus, Pallas, l. c.
Dauurische Krebs, Herbst, Versuch Naturgesch. Krabben u. Krebse, II. 42, 1796. (After Pallas.)
Astacus leptorrhinus, Fischer, Bull. Soc. Impér. Nat. Moscou, IX. 467, Tab. V. fig. 1, 1836.
Astacus Dauricus, Erichson, Arch. Naturgesch., XII. Jahrg., I. 94, 1846.
Astacus Dauricus, Gerstfeldt, Mém. Acad. Impér. Sci. St. Pétersbourg, VIII. 292, 1859.
Astacus Dauricus, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 361, 1874.
Astacus (*Cambaroides*) *Dauricus*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 151, 1884.

Habitat. — Upper portion of the Amoor River basin as far down as Albasin, including the rivers Ingoda, Argoon, Onon, Shilka, and Nercha. It is not found in the Gasimoor, a tributary of the Argoon (Gerstfeldt, Kessler).

3. Astacus (Cambaroides) Schrenckii.

Plate VI. fig. 3.

Astacus Schrenckii, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 363, 1874.
Astacus (*Cambaroides*) *Schrenckii*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 151, 1884.

Habitat. — Lower part of the basin of the Amoor River (Kessler).

In the form of the rostrum and in the possession of a lateral thoracic spine, *A. Schrenckii* bears less resemblance to *A. Dauricus*, from the upper part of the same river basin, than *A. Japonicus* does. On the other hand, the chelæ and abdominal pleura of *A. Schrenckii* are very much like those of *A. Dauricus*, while in *A. Japonicus* the chelæ are much shorter and broader, the abdominal pleura broader and more rounded, than in the Amoorland species.

* The epipodite of the first maxilliped bears no branchial filaments.

In the remaining species of Astacus the first abdominal appendages are simply rolled, never bifid nor toothed at the end, neither are there hooks on any of the thoracic legs in the male.

THE NORTH AMERICAN ASTACI.

Six species of Astacus have been described from Western North America, viz.: — *A. Oregonus* Randall, 1839; the type of this species was lost, and the figure and description are insufficient for its determination; it is perhaps the same as *A. leniusculus* Dana. *A. Gambelii* Agassiz, first described as a Cambarus in 1852 by Girard; the types of Girard are in the Philadelphia Academy. *A. leniusculus* Dana, 1852; type in the collection of the Smithsonian Institution, Washington, D. C. *A. nigrescens*, *A. Trowbridgii*, and *A. Klamathensis*, described by Stimpson in 1857; there are types of *A. Trowbridgii* in the Smithsonian Institution, the Museum of Comparative Zoölogy, and the Peabody Museum of Yale College; Dr. Hagen examined types of *A. nigrescens* and *A. Klamathensis* communicated by Stimpson.

Distribution. — The nearly related species *A. leniusculus* and *A. Trowbridgii* are found in the lower part of the Columbia River, Puget Sound, and adjacent regions. To the southward near the coast, in the neighborhood of San Francisco, *A. nigrescens* appears to be the dominant species. It perhaps extends northward near the coast as far as Alaska. In the more elevated regions of the Northwest, in Oregon, Washington Territory, and British Columbia, *A. Klamathensis* is found. The most eastern of the American Astaci is *A. Gambelii*, which is found in the Great Salt Lake Valley and in the upper waters of the Snake River, Idaho. From this region it has passed over the divide into the Yellowstone Valley, and invaded the domain of the Cambari as far as the confluence of the Yellowstone and Missouri Rivers. An examination of the physical geography of this region shows that the migration of a Western species into the Mississippi basin at this point is no difficult matter, the divide separating the waters of the Yellowstone from those of the Snake River being very low, hardly above the level of the ancient Yellowstone Lake.*

Compared with the European species, the American Astaci have the

* See W. H. Holmes's Report on the Geology of the Yellowstone National Park, in Twelfth Ann. Rep. U. S. Geolog. and Geograph. Survey of the Territories for 1878, Part II. p. 56, 1883.

telson less clearly divided by a transverse suture, and the first pair of male appendages are more closely rolled, with a more pointed and membranaceous tip.

I have examined the branchiæ of *A. Klamathensis*, *A. nigrescens*, and *A. Gambelii*. In all of them the formula is the same as for *A. fluviatilis*, there being three rudimentary gills on each side of the thorax. In *A. nigrescens* the two anterior ones are short, but thick. They are more highly developed in *A. Gambelii* than in any other species of Astacus examined, presenting an interesting approach in structure to the perfectly developed gill. Each of the rudimentary gills is much larger than in any other species, and is jointed at a short distance from the base. At the joint there are, in the intermediate pair, two short lateral branches, one on each side; in the anterior and posterior pairs the main stem bears one lateral filament.

I find no trace of appendages on the first abdominal somite of the female in any of the American species of Astacus.

The five American species of Astacus may be distinguished as follows: —

A. Margins of the rostrum not denticulated.
  a. Rostrum short, with short acumen. Post-orbital ridge without posterior spine. *A. Klamathensis.*
  b. Rostrum long, with long acumen. Post-orbital ridge with a posterior spine or tubercle.
    a. Posterior spine of post-orbital ridge long and acute. Areola one half as broad as long . . . . . *A. leniusculus.*
    β. Posterior spine of post-orbital ridge small, sometimes reduced to a tubercle. Areola one third as broad as long . . . . . *A. Trowbridgii.*
B. Margins of the rostrum denticulated.
  a. Rostral acumen long. Posterior spine of post-orbital ridge prominent. Chela not barbated . . . . . *A. nigrescens.*
  b. Rostral acumen short. No posterior spine on post-orbital ridge. Chela barbated . *A. Gambelii.*

1. Astacus Klamathensis.

Plate VI. figs. 1, 2.

Astacus Klamathensis, Stimpson, Proc. Bost. Soc. Nat. Hist., VI. 87, February, 1857. — Journ. Bost. Soc. Nat. Hist., VI. 494, April, 1857.

Astacus Klamathensis, Spence Bate, in Lord's "Naturalist in Vancouver Island and British Columbia," II. 278, 1866. (No description.)

Astacus Klamathensis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 93, Pl. III. fig. 169, 1870.

Astacus Klamathensis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 151, 1884.

Known Localities. — Oregon: Klamath Lake (Stimpson); Sikan Creek; Des Chutes River. Washington Terr.: Fort Walla Walla; Wenas Valley; Spokane Falls. British Columbia: streams east of the Cascades (Bate).

Stimpson's types were found in Klamath Lake by Dr. Newberry. One of these, a female, was described by Hagen. It is common at Fort Walla

Walla, judging from the number collected at that place by Captain Charles Bendire, U. S. A. These specimens are in the U. S. National Museum.

Specimens from Sikan Creek, Oregon, differ in some respects from those received from Washington Territory, the sides of the rostrum converging more (as described by Stimpson and Hagen in the Klamath Lake specimens) and ending in a longer acumen. In the specimens from Fort Walla Walla the rostrum is quadrangular, with shorter acumen. In the Oregon specimens the cervical groove is more broadly sulcate, the posterior portion of the cephalothorax broader, the carapace impressed on each side of the median line of the cardiac region and less densely punctate; the abdomen of the female is more expanded anteriorly, the internal margin of the antennal scale tapers off more gradually from the middle to the tip, and the hand is longer.

In small specimens of *A. Klamathensis* there is a sharp spine at the antero-interior angle of the carpus; the rostral acumen is longer, and the post-orbital spines longer and sharper than in the adult.

In some adult specimens a faint trace of a posterior post orbital spine is to be seen on close examination as a minute brown-horny granule, similar in appearance to the tip of the front end of the post-orbital ridge. This granule occupies exactly the place of the hinder post-orbital spine of *A. Trowbridgii*, etc.

Length, 95 mm.

2. Astacus leniusculus.

Plate VI. fig. 4.

Astacus leniusculus, Dana, Crustacea U. S. Explor. Exped., Pt. I. p. 524, Pl. XXXIII. fig. 1, 1852.
Astacus leniusculus, Stimpson, Journ. Bost. Soc. Nat. Hist., VI. 493, 1857.
Astacus leniusculus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 94. (After Dana and Stimpson.)
Astacus leniusculus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 151, 1884.

Known Localities. — Washington Territory: Columbia River; Puget Sound (Dana, Stimpson).

One of Dana's types is in the collection of the Smithsonian Institution (U. S. Explor. Exped., No. 375, Smithson. Inst., No. 2019). The rostrum of this specimen, a male, is mutilated and deformed. Two more male specimens are in the same Museum (Cat. No. 2161) without any label indicating their origin.*

The hands are of unequal size, the left being the larger. Dana says that

* One of these is now in the Museum of Comparative Zoölogy (Cat. No. 3655). This is the one figured on Plate VI. of this work.

in young specimens the posterior spines of the carapace are obsolescent and the hands of nearly equal size. Judging from his figure, 1 *b*, the postcarapace is also longer. Perhaps these young specimens were *A. Trowbridgii* Stimpson.

A. leniusculus is closely related to *A. Trowbridgii*. For the distinctions, see under the latter species.

The posterior margin of the anterior segment of the telson is bi- or tri-spinous on each side. The cone at the orifice of the green gland ("auditory tubercle") terminates in a sharp spinule; in *A. Trowbridgii* it is blunt. The spines on the second and third segments of the antennæ are prominently developed and acute. The anterior process of the epistoma is triangular, similar in form to that of *A. Trowbridgii*. The fingers are spinulose at the distal ends, as in *A. Trowbridgii*.

Astacus Oreganus.

Astacus Oreganus, Randall, Journ. Acad. Nat. Sci. Phila., VIII. 138, Pl. VII., 1839.
Astacus Oreganus, De Kay, Zoölogy of New York, Pt. VI., Crustacea, p. 23, 1844. (After Randall.)
Astacus Oreganus, Erichson, Arch. Naturgesch., XII. Jahrg., I. 375, 1846. (After Randall.)
Cambarus Oreganus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 87, 1852. (After Randall. No description.)
Astacus Oreganus, Stimpson, Journ. Bost. Soc. Nat. Hist., VI. 495, 1857. (After Randall.)
Astacus Oreganus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 95, 1870. (After Randall.)

"Testa granulata, bimaculata, fronte valde producta.

"Body fuscous, granulated, carpus with a sharp spine at the inner angle; arm produced into a spine on each side anteriorly; thorax behind the front with five spines, placed three before and one on each side behind the lateral ones; a large reddish spot on each side posteriorly; front little reflexed on the sides, terminating in a very long slender spine, and having a short marginal spine on each side.

"Length about four inches.

"Taken by Mr. Nuttall in the Columbia River, west coast of North America."—Randall.

The type of *A. Oreganus* was lost or destroyed while in the hands of the artist by whom the drawing was made,* and no specimen answering to the description and figure has since been found. The figure given by Randall is very faulty, as has been pointed out by Hagen. The tri-articulate structures interpreted by Hagen as badly drawn antennal scales are, I think, the three distal segments of the third maxillipeds, the antennal scale not being represented at all. Dr. Hagen thinks that the median spine at the base of the rostrum may be a carinated elevation simply, such as is seen in *A. nigrescens* (he might have added also *A. Trowbridgii* and *A. leniusculus*). The drawing might well be thus explained, but it is hard to make Randall's explicit mention of *five* spines accord with such an interpretation. I incline, nevertheless, to Dr. Hagen's opinion, that this specimen was no other than *A. leniusculus* Dana. The short post-carapace and long rostral acumen agree better with that species than with *A. Trowbridgii*.

* See Proc. Acad. Nat. Sci. Phila., V. 30.

3. Astacus Trowbridgii.

Astacus Trowbridgii, Stimpson, Proc. Bost. Soc. Nat. Hist., VI. 87, February, 1857.—Journ. Bost. Soc. Nat. Hist., VI. 493, April, 1857.
Astacus Trowbridgii, J. G. Cooper, Rep. U. S. Pacific R. R. Expl., XII. Pt. II. 388, 1860.
Astacus Trowbridgii, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 93, Pl. III. fig. 171, Pl. X., 1870.
Astacus Trowbridgii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 152, 1884.

Known Localities. — Oregon: Columbia River, near Astoria. Washington Territory: streams running into Shoalwater Bay (J. G. Cooper).

There are types of *A. Trowbridgii* in the collections of the U. S. National Museum, the Peabody Museum of Yale College, the Boston Society of Natural History, and the Museum of Comparative Zoölogy. There are also two specimens in the Academy of Natural Sciences of Philadelphia. One of the two female types in the collection of the Boston Society of Natural History is figured by Hagen. The spine on the third segment of the antenna is commonly longer than represented by Hagen.

In the larger specimens the posterior pair of spines on the carapace may be obsolete, while in other specimens these spines, although smaller than the anterior pair, are well developed, with acute, brown, horny tips.

The dimensions of a large specimen as given by Stimpson are as follows: — Length of body, 4.80 in.; breadth, 1.30 in. Length of rostrum, 0.50 in.; acumen of rostrum, 0.18 in.; hand, 2.60 in.; breadth of hand, 1.15 in.

The areola is two and one half times as long as it is broad. The distance from the tip of the rostrum to the cervical groove is but a trifle more than twice the distance from the cervical groove to the posterior margin of the carapace. The length of the acumen of the rostrum is equal to the distance between the lateral spines of the rostrum. The tips of the first pair of abdominal appendages of the male are delicately membranous.

Of the eleven specimens (six males, five females) which I have seen, nine are types collected by Lieut. Trowbridge in the Columbia River above Astoria, Oregon. Of the other two, in the Philadelphia Academy, one is labelled Columbia River, the other is without locality. According to Cooper, it is also found in the streams running into Shoalwater Bay, Washington Territory, to the north of Columbia River, and even in the brackish water of the bay. According to the same authority, its color, when fresh, is olive above; pale, tinted with red, below.

A. Trowbridgii is closely related to *A. leniusculus*. It differs from it in the following particulars: the body is more obese; the cephalothorax is broader

posteriorly, in *A. leniusculus* more cylindrical; the carapace is less punctate and less ciliate; the rostrum is shorter and broader, with shorter acumen, the distance between the lateral spines of the rostrum being equal to the length of the acumen, whereas in *A. leniusculus* the length of the acumen much exceeds the distance between the lateral spines; the length of the part of the carapace posterior to the cervical suture is greater, being very nearly equal to half the distance from the cervical groove to the tip of the rostrum, while in *A. leniusculus* the latter distance is twice and one half the distance from the cervical groove to the posterior margin of the carapace; the areola is longer and narrower, considerably more than twice as long as broad, while in *A. leniusculus* it is much less than twice as long as broad; the spines on the carapace behind the eyes are less developed, especially the posterior ones, and the chela is broader.

4. Astacus nigrescens.

Astacus nigrescens, Stimpson, Proc. Bost. Soc. Nat. Hist., VI. 87, February, 1857. — Journ. Bost. Soc. Nat. Hist., VI. 492, April, 1857.
Astacus nigrescens, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 92, Pl. III. fig. 168, 1870.
Astacus nigrescens, Huxley, The Crayfish, p. 244, fig. 61, C, F, I, fig. 62, C, F, 1880.
Astacus nigrescens, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 152, 1884.

Known Localities. — California: San Francisco; Washington Territory: Fort Steilacoom (Coll. U. S. Nat. Mus.). Alaska Territory: Oonalaska (Coll U. S. Nat. Mus.).

In most specimens the post-orbital ridges are reduced to an anterior and posterior spine, but in some there is a third spine between these two. The ridge that represents the annulus ventralis of the female Cambarus is broadly notched in the middle.

A female specimen in the U. S. National Museum, from Fort Steilacoom, Washington Territory (No. 2526), differs as follows from the typical form: the sides of the rostrum are less inflated and more convergent, the acumen shorter; the margin of the telson has only one spine on each side; the hand is shorter, smoother, more coarsely punctate, the spines of the meros less developed; the branchial regions of the carapace and the abdominal pleura are more coarsely punctate.

A male specimen in the same Museum is labelled "Oonalaska, W. H. Dall." The rostrum of this specimen (No. 8954) is aborted and deformed, the chela longer than usual. The locality, if correct, is an interesting one.

Another large male specimen, five inches long, in the U. S. National Museum, from T. G. Scupham, California (No. 2267), is labelled "*Astacus Oregonensis* Nutt.," and by this name it is recorded by W. H. Dall in his "Catalogue of Illustrations of the Economical Invertebrates of the American Coasts," Bull. U. S. Nat. Mus, No. 14, p. 260, 1879. Randall's *A. Oregonus* was collected by Nuttall in the Columbia, but was certainly not *A. nigrescens*. (See p. 133.)

Types of *A. nigrescens* were sent to Dr. Hagen by Stimpson. These were probably afterwards destroyed in the great fire at Chicago.

It is said by Stimpson to be common in the vicinity of San Francisco, and to be sold in the market of that city.

"Color, blackish." Stimpson.

The first abdominal appendages of the male *A. nigrescens* are incorrectly figured by Huxley in "The Crayfish," p. 245, fig. 62, C, and by Brocchi in Ann. Sci. Nat., 6e Sér., Zool. et Paléont., Tom. II., Pl. XIII. figs. 10, 11.

5. Astacus Gambelii.

Cambarus Gambelii, Girard, Proc. Acad. Nat. Sci. Phila., VI. 90. 1852, 380, 1853.
Astacus Gambelii, Agassiz, Proc. Acad. Nat. Sci. Phila., VI. 375, 1853.
Astacus Gambelii, Stimpson, Journ. Bost. Soc. Nat. Hist., VI. 492, 1857.
Astacus Gambelii, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 90, Pl. I. figs. 97, 98, Pl. III. fig. 170, Pl. XI. 1870.
Astacus Gambelii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 152, 1884.

Known Localities. — Utah: Ogden River, Ogden. Idaho: Fort Hall (Coll. U. S. Nat. Mus.); west side of Teton Basin (Coll. U. S. Nat. Mus.). Montana: mouth of Yellowstone River. Wyoming: Willow Creek (?). California: Santa Barbara (?).

Girard's types are in the Museum of the Academy of Natural Sciences of Philadelphia. One of them has been figured by Hagen.

The female, as well as the male, has the peculiar beard on the chela. The lower side of the peduncles of the antennæ is also barbate in both sexes. In some specimens the telson is notched in the middle of the hind border, in other specimens it is entire.

Two dozen fine specimens of this species were collected by Mr. J. A. Allen at Ogden, Utah, in September, 1871. The largest of these measure 95 mm. in length. Ogden City is on Ogden River, which flows into Great Salt Lake. In the U. S. National Museum are specimens from a warm spring at Fort Hall, and from the west side of Teton Basin. Both of these locali-

ties are in Idaho, in the upper part of the area drained by the Lewis Fork of the Columbia River. There are also four small specimens collected by the Hayden Survey at the mouth of the Yellowstone River, which joins the Missouri River at the western boundary of Dakota. Besides these there are two young specimens in the same collection, labelled "Willow Creek, Oct. 9, 1872, Dr. Curtis." An added ticket reads "Wyoming Terr.?" Willow Creek in Wyoming Territory flows into the South Fork of the Platte River, another affluent of the Missouri. The correctness of the tickets accompanying the Yellowstone River specimens is at any rate unquestioned, and it thus appears that this species has encroached upon the territory of Cambarus in the area drained by tributaries of the Missouri River. The Teton Basin specimens, it will be observed, come from a locality not far from the water-shed dividing the waters which flow into the Pacific Ocean from those which find their outlet in the Gulf of Mexico.*

Girard's types, collected by Dr. Gambel, are said to have come from California; but whether they were taken within the present limits of that State I do not know. The only other specimens of *A. Gambelii* seen by me which could possibly have come from California are a few in the U. S. National Museum (No. 4855), labelled, "Found in bottle containing specimens from Santa Barbara, Dr. Webb." I doubt whether these were collected at Santa Barbara. I have seen no authentic specimens from California.

THE EUROPEAN ASTACI.

In addition to the long and well known *Astacus fluviatilis* Auct., several European forms have been described and named as distinct species from time to time, so that there now stand on record eleven nominal species from within the limits of Europe, viz.: *Astacus fluviatilis* Rondelet (1555), *Cancer torrentium* Schrank (1803), *A. leptodactylus* Eschscholtz (1823), *A. saxatilis* Koch (1835?), *A. tristis* Koch (1835), *A. angulosus* Rathke (1836), *A. pachypus* Rathke (1836), *A. Caspius* Eichwald (1838), *A. longicornis* Lereboullet (1858), *A. pallipes* Lereboullet (1858), and *A. fontinalis* Carbonnier (1869). To these was added a twelfth closely allied species, *A. Colchicus* Kessler (1876), from the Rion River, south of Mount Caucasus.

In 1846 all the Astacidæ described down to that date underwent a re-

* See page 130.

vision by Erichson.* Of the described European species, *A. angulosus* Rathke, *A. pachypus* Rathke, and *A. Caspius* Eichwald, were known to Erichson only through the previous descriptions. He suggests that *A. Caspius* may prove to be the same as *A. pachypus*, a surmise that was afterwards shown by Gerstfeldt to be just. Erichson had the opportunity to examine Koch's types of *A. torrentium*, *saxatilis*, and *tristis*, and notes their clear specific separation from *A. fluviatilis*, and their close affinity with each other. He shows that the dark color of *A. tristis* is due to a coating of adhesive mould, and dismisses the question of the specific value of the differences with the remark that the distinctions may have been more evident in living specimens.

In 1859 the European Astaci were subjected to a second revision at the hands of Gerstfeldt.† The material at Gerstfeldt's command was rich in specimens from Russia, but poor in examples from Central and Western Europe. Gerstfeldt reaches the conclusion, that all the described European species of Astacus may be reduced to two valid species, *A. fluviatilis* and *A. torrentium* (Steinkrebs). He justly points out the identity of *A. pachypus* Rathke and *A. Caspius* Eichwald, and further claims that *A. leptodactylus* Eschscholtz, *A. angulosus* Rathke, and *A. pachypus* Rathke, are but varieties of *A. fluviatilis*, resulting from conditions of climate and of the water inhabited by the several forms. Of the so-called Steinkrebse of the central and western parts of Europe, Gerstfeldt appears to have had but five specimens, all from the Rhone. These he regards the same with *Cancer torrentium* Schrank, *A. saxatilis* Koch, *A. tristis* Koch, and *A. longicornis* Lereboullet. In reality Gerstfeldt's Steinkrebse belonged to the species described and figured the previous year (in a memoir unknown to Gerstfeldt) by Lereboullet,‡ under the name *A. pallipes* (Dohlenkrebs), a distinct form from *Cancer torrentium* Schrank (= *A. saxatilis*, *tristis*, and *torrentium* of Koch, *A. longicornis* of Lereboullet).

In 1869 Heller § described five species from Southern Europe; viz. *A. fluviatilis* Rondelet, *A. leptodactylus* Eschscholtz, *A. angulosus* Rathke, *A. pachypus* Rathke, and "*A. saxatilis* Koch." As synonymes of *A. saxatilis*, Heller includes *A. saxatilis* Koch, *A. tristis* Koch, *A. torrentium* Schrank et Koch, and *A. fluviatilis* Bell. Heller's *A. saxatilis* is the species described by Lereboullet

* Uebersicht der Arten der Gattung Astacus. Arch. Naturgesch., XII. Jahrg., pp. 86–103, 1846.

† Ueber die Flusskrebse Europa's. Mém. Acad. Impér. Sci. St. Pétersbourg, IX. 549–589, 1859.

‡ Description de deux nouvelles Espèces d'Écrevisses de nos Rivières. Mém. Soc. Sci. Nat. Strasbourg, Tom. V., 1858, 11 pp. 3 pl.

§ Die Crustaceen des südlichen Europa. Crustacea Podophthalmia, pp. 212–218, Taf. VII. figs. 3–6, 1863.

as *A. pallipes* (= *A. fluviatilis* Bell), and not *A. saxatilis* Koch (= *A. torrentium* Schrank).

A careful treatise by Kessler* on the Astaci found within the territory of the Russian Empire appeared in 1874. With regard to the European forms, Kessler, in opposition to Gerstfeldt, decides that *A. fluviatilis* Auct., *A. pachypus* Rathke (= *A. Caspius* Eichwald), and *A. leptodactylus* Eschscholtz, are good species, while he considers *A. angulosus* to be a local variety of *A. leptodactylus* which has arisen in the stony mountain streams of the Crimea and Caucasus. Kessler has had unrivalled facilities for forming a correct judgment concerning the specific value of the different forms of Russian crayfishes, hundreds of specimens of both sexes and of different stages of development having passed through his hands. His direct testimony as to the absence of intermediate forms between the three species indicated above appears to me conclusive, and a careful study of all the material accessible leads me to coincide entirely with his views.

The Astaci of Middle and Southern Europe were revised in 1882 by Klunzinger,† who confirms Lereboullet in his conclusion that there are two species besides *A. fluviatilis* in that part of Europe which lies to the west of Russia. To Lereboullet's *A. longicornis* he restores the older name of Schrank, *A. torrentium* (= *A. saxatilis*, *tristis*, and *torrentium* of Koch). The distinctions between this species and *A. pallipes*, or the Dohlenkrebs of Lereboullet, are given in detail, and the identity of the latter with *A. saxatilis* of Heller, the Steinkrebs from the Rhone of Gerstfeldt, and probably with *A. fontinalis* of Carbonnier, is pointed out.

The twelve nominal species enumerated above are thus reduced to six: *A. fluviatilis* Rond., *A. torrentium* (Schrank), *A. leptodactylus* Eschsch. (with var. *angulosus*), *A. pachypus* Rathke, *A. pallipes* Lereb., and *A. Colchicus* Kessl.

In *Astacus fluviatilis* there are three rudimentary pleurobranchiæ on each side of the body, upon the tenth, eleventh, and twelfth body-segments,‡ while in *A. pallipes* there are but two, the anterior one being aborted.§ In the place of the anterior one a small papilla can be discerned, evidently the last vestige of the lost branchia. I have further examined the branchiæ of

* Die Russischen Flusskrebse. Vorläufige Mittheilung. Bull. Soc. Impér. Nat. Moscou, XLVIII. 343–372, 1874.

† Ueber die Astacus-Arten in Mittel- und Südeuropa und den Lereboullet'schen Dohlenkrebs insbesondere. Jahreshefte d. Vereins f. vaterländische Naturkunde in Württemberg, XXXVIII. Jahrg., pp. 326–342, 1882.

‡ Counting the antennulary somite as the first.

§ The difference in the number of rudimentary pleurobranchiæ in *A. fluviatilis* and *A. pallipes* was first noticed by Huxley, The Crayfish, p. 295, 1880.

A. torrentium, *A. leptodactylus*, and *A. Colchicus*. The first of these possesses two rudimentary pleurobranchiæ on each side of the body, like *A. pallipes*; of the anterior pleurobranchia I find not the slightest trace. In *A. leptodactylus* and *A. Colchicus* three are present, although in the former the second and third are very short.

In so far as the reduction of the branchiæ can be taken as a clew to the affinities of the various species of European Astaci, *A. pallipes* and *A. torrentium* are the furthest removed from the primitive form. This accords with Huxley's suggestion, that the Ponto-Caspian species are the modern representatives of the original Eastern stock, while the "Stone Crayfishes"* represent an ancient offshoot, or western wave of migration, which was followed by an invasion of *A. fluviatilis*, just as at the present day, according to Kessler, the latter species is in its turn succumbing to *A. leptodactylus* in the Baltic area.† Following up this line of thought, we must conclude that, of the two species *A. torrentium* and *A. pallipes*, the former represents the older offshoot from the original stock, an offshoot which has retreated before the invading *A. pallipes* to the mountain regions of Central Europe. For not only in the condition of its branchiæ, but also in its general form, *A. pallipes* stands between *A. torrentium* and *A. fluviatilis*.‡

In the European Astaci the first abdominal segment of the female carries a pair of small, simple appendages. They are smaller than in the genus Cambarus, but not aborted,§ as in the American Astaci, in Cambaroides, and in the Parastacinæ of the Southern hemisphere.

In *A. torrentium* and *A. pallipes* the first abdominal appendages of the male are divided into two lobes at the tip by a shallow cleft, the inner and the outer parts being of about equal length. In the other species the outer part is truncate, while the inner part projects beyond it. In *A. pachypus* and *A. Colchicus* the projecting tip of the inner part is longer than in *A. fluviatilis* and *A. leptodactylus*.

The European Astaci, including *A. Colchicus* from the Rion River, Transcaucasia, may be distinguished by the following table: —

* I. e. *A pallipes* and *A. torrentium*, which Huxley confounds together as one species.

† Vide Huxley, *op. cit.*, p. 321.

‡ Klunzinger (*op. cit.*, p. 331) goes so far as to assert that *A. pallipes* is more closely related to *A. fluviatilis* than to *A. torrentium*, but it does not seem so to me. *A. fluviatilis*, *A. leptodactylus* (including the form *A. angulosus*), *A. pachypus*, and *A. Colchicus* form a natural group of closely related species opposed to the group containing the two Western species, *A. pallipes* and *A. torrentium*.

§ Huxley affirms, however, that these appendages are sometimes wanting in English crayfishes (*A. pallipes*). The Crayfish, p. 146.

A. One tubercle on each side of the base of rostrum.
  a. Tip of rostrum not exceeding the distal end of the penultimate segment of antennule. Rostrum not carinate at the tip. No spines on the sides of the carapace behind the cervical groove . . . . . *A. torrentium.*
  b. Tip of rostrum almost attaining the distal end of the terminal segment of the antennule. A keel or median crest near the tip of the rostrum. One or more spines on the sides of the carapace behind the cervical groove . . . . . *A. pallipes.*

B. Two tubercles, one behind the other, on each side of the base of the rostrum.
  a. Margin of rostrum not denticulate.
    α. Margin of rostrum granulated, not continued back of the anterior post-orbital tubercle. Posterior post-orbital tubercle slightly developed . . . . . *A. fluviatilis.*
    β. Margin of rostrum smooth, continued back on the carapace as a distinct ridge as far as the posterior post-orbital tubercle. Posterior post-orbital tubercle well developed, provided with a spine . . . . . *A. Colchicus.*
  b. Margin of rostrum denticulate.
    α. Chela flat. Rostrum longer than peduncle of antennule. Basal angle of external border of antennal scale spinous . . . . . *A. leptodactylus.*
    β. Chela thick. Rostrum equal in length to peduncle of antennule. Basal angle of external border of antennal scale not spinous . . . . . *A. pachypus.*

6. Astacus torrentium.

Cancer torrentium (Steinkrebs), Schrank, Fauna Boica, III. 247, 1803.
Astacus torrentium (Steinkrebs), Wolf, Mag. neuesten Zustand Naturkunde, herausgegeb. v. Johann Heinrich Voigt, XI. 42–45, Taf. I. figs. 1, 2, 1806.
Astacus saxatilis, Koch, Deutschlands Crustaceen, Myriapoden und Arachniden, Heft 7, No. 1, with fig. (Panzer and Herrich-Schäffer's Deutschlands Insecten, Heft 140, No. 1), 1835?
Astacus tristis, Koch, *op. cit.*, Heft 7 (140), No. 2, with fig., 1835?
Astacus torrentium, Koch, *op. cit.*, Heft 36 (186), No. 24, with fig., 1841.
Astacus torrentium, Erichson, Arch. Naturgesch., XII. Jahrg., I. 92, 1846.
Astacus saxatilis, Erichson, *op. cit.*, p. 92, 1846.
Astacus tristis, Erichson, *op. cit.*, p. 93, 1846.
Steinkrebs, Lereboullet, Comptes Rendus Acad. Sci. Paris, XXXIII. 379, 1851.
Astacus longicornis, Lereboullet, Mém. Soc. Sci. Nat. Strasbourg, V. 2 (separate pagination), Pl. I. figs. 2–2d, 1858.
Astacus torrentium (Steinkrebs) (in part), Gerstfeldt, Mém. Acad. Impér. Sci. St. Pétersbourg, IX. 574, 579, 581, 584, 1859. (After Koch, Erichson, and Lereboullet.)
Astacus torrentium (Steinkrebs), Klunzinger, Jahresh. Vereins vaterländl. Naturkunde Württemberg, XXXVIII. Jahrg., p. 340, 1882.
Astacus torrentium, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 153, 1884.

Koch's *A. saxatilis*, *A. tristis*, and *A. torrentium* are without doubt one and the same species, equivalent to *A. torrentium* (Schrank) Wolf. According to Koch, *A. saxatilis* is distinguished by a slightly carinated rostrum, whereas in *A. tristis* and *A. torrentium* the rostrum is not carinated; but Erichson, who examined Koch's types, tells us that there is an indication of a median rostral carina in *A. tristis* and *A. torrentium* also. The carina is certainly shown in an exaggerated form in all of Koch's figures. The dark color of *A. tristis* came from a coating of mould, according to Erichson, and the broad abdomen is simply a sexual character.

The best illustrations of this species are Lereboullet's (under the name *Astacus longicornis*).

Klunzinger's memoir clearly brings out the specific characters of this species and *A. pallipes*.

Although a faint median rostral carina may exist in *A. torrentium*, it never rises into a prominent sharp crest near the tip, as in *A. pallipes*. Commonly there is no spine on the lower side of the first antennulary segment, but in a specimen in the Museum of Comparative Zoölogy, without locality, I find it quite well developed, as it always is in *A. pallipes*.

I have examined the gills of this species in a specimen from Bohemia in the U. S. National Museum, and find them to agree in number and disposition with those of *A. pallipes*. See page 140.

Distribution. — *Astacus torrentium* is found in the central part of Europe, especially in Germany; but as it has been confounded generally by authors with *A. pallipes* and *A. fluviatilis*, the data are insufficient to determine the limits of its distribution. It is not found to the eastward within the territory of Russia (Kessler). I have seen a specimen (in U. S. National Museum) from Bohemia. It is widely spread through Bavaria and Würtemberg in the mountain lakes, and in the brooks and rivers of the Danube and Neckar river systems. Particular localities recorded in Bavaria are Würm-See (Schrank, *op. cit.*, p. 247; Wolf, *op. cit.*, p. 42; *A. fluviatilis* also inhabits the same lake); mountainous parts of Oberpfalz; near Bodenstein; also in the Danube (Koch) and Kochel-See (Klunzinger). In Würtemberg it has been found in the Neckar, the Nagold, and various small streams of the Neckar and Danube basins (Klunzinger). It is also found in Alsace in the rivers Ill and Bruche, near Strasburg (Lereboullet). How far to the northward it extends in Germany, and whether it passes to the west into France, I cannot determine. All the French specimens which I have seen are *A. pallipes* and *A. fluviatilis*. On the whole, it would seem that *A. torrentium* is a form chiefly found in the mountainous and upland regions of Central Europe.

7. Astacus pallipes.

? *Astacus astacus*, Pennant, British Zoölogy, IV. 18, Pl. XV. fig. 27, 1777.

? *Astacus fluviatilis*, Leach, Trans. Linn. Soc. London, Vol. XI. Pt. II. p. 344, 1815. (No description.)

Astacus fluviatilis (in part), Milne Edwards, Hist. Nat. Crust., II. 330, 1837. (First "variety" noted on p. 331.) — Cuvier's Règne Animal, Disciples' ed., Crustacés, Pl. XLIX. fig. 2.

Dahlenkrebs, Lereboullet, Comptes Rendus Acad. Sci. Paris, XXXIII. 376, 1851. (Treated as a variety of *A. fluviatilis*.)

Astacus fluviatilis, Bell, Hist. British Stalk-eyed Crustacea, p. 237, with cut, 1853.

Astacus pallipes, Lereboullet, Mém. Soc. Sci. Nat. Strasbourg, V. 7 (separate pagination), Pl. II., III. figs. 3–3 d, 1858.

Astacus pallipes, var. *flavus*, Lereboullet, Mém. Soc. Sci. Nat. Strasbourg, V. 9, 1858.

Astacus torrentium (Steinkrebs) (in part), Gerstfeldt, Mém. Acad. Impér. Sci. St. Pétersbourg, IX. 577, 1859.

Astacus saxatilis, Grube, Ein Ausflug nach Triest und dem Quarnero, p. 73, 1861.

Astacus saxatilis, Heller, Die Crustaceen des südlichen Europa, p. 217, Taf. VII. figs. 3, 5, 1863.

Astacus fontinalis (l'écrevisse à pieds blancs), Carbonnier, L'Écrevisse, p. 8, 1869.

Potamobius astacus, G. B. Sowerby, Continuation of Leach's Malacostraca Podophthalma Britanniæ, Nos. XVIII., XIX., Tab. XXXIV. fig. 1, 1875.

Astacus fluviatilis, Huxley,* The Crayfish, *passim*, and p. 230 in particular, Frontispiece and figs. 1–60, 1880.

Astacus torrentium, Huxley,* *op. cit.*, p. 296, fig. 61, a, d, g, fig. 62, a, d, 1880.

Astacus pallipes (der Dohlenkrebs), Klunzinger, Jahresh. Vereins vaterland. Naturkunde Württemberg, XXXVIII. Jahrg., p. 341, 1882.

Astacus pallipes, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 154, 1884.

Under the name "Steinkrebs" the older authors appear to have confounded *A. torrentium* and *A. pallipes*. They were first separated as distinct species in 1858 by Lereboullet with the names *A. longicornis* and *A. pallipes*. Gerstfeldt (1859) seems to have had very little material from without the bounds of the Russian Empire. Of the "Steinkrebs" he had seen only five ill-preserved dried examples from the Rhone, which, as appears from his description of them (p. 577), belong to *A. pallipes*. He considers them to be the same species as that described by Schrank and Koch, i. e. *A. torrentium*. Compared with *A. torrentium*, *A. pallipes* has a narrower rostrum with a longer and narrower acumen; the median keel is more evident, especially near the tip of the rostrum; the antennæ are shorter, and the peduncle of the antennæ overreaches the tip of the rostrum by only a small fraction of the length of the terminal segment, while in *A. torrentium* it surpasses the rostrum by the whole length of the terminal segment; the longitudinal ridge on the lower face of the antennal scale is not toothed, as in *A. torrentium*; behind the cervical suture are several lateral spines; the chelæ are more coarsely and sparsely tuberculate. For a detailed comparison of these two species, see Klunzinger, *op. cit.*

A. pallipes and *A. torrentium* have a rudimentary pleurobranchia on each side of the penultimate and antepenultimate somites. In all the other species of Astacus which I have examined there is a third pair on the preceding somite. The first abdominal appendages of the male *A. pallipes* are figured by Brocchi, Ann. Sci. Nat., 6e Sér., Zool. et Paléontol., Tom. II., Pl. XIII. figs. 12, 13 ("*Astacus fluviatilis*" from Vaucluse). They agree in form

* Huxley leaves the question of the specific or the varietal value of the forms *A. nobilis* and *A torrentium* (= *A. fluviatilis* and *A. pallipes*) undecided.

with those of *A. torrentium*, and differ from those of the other European species, as pointed out on page 140.

Distribution. — *Astacus pallipes* appears to be found chiefly in Southern and Western Europe. According to Kessler, it is not found in Russia. Grube collected it in Lake Vrana in the island of Cherso. Heller records it from Greece, Dalmatia, the island of Veglia, Trieste, Lake Garda, and Genoa. In France it is apparently common in the valley of the Rhone (I have seen specimens from Fontaine de Vaucluse and from Lyons),* and has perhaps passed from this valley into that of the Rhine, where it is known from Lake Neufchâtel (at Montagny and Neufchâtel), and from the neighborhood of Strasburg. In the last-named region *A. torrentium* and *A. fluviatilis* are also found (Lereboullet). The passage of the southern *A. pallipes* into Alsace would be facilitated by the Rhine and Rhone Canal, as Klunzinger has remarked.† According to the older authors, crayfishes are not found in Spain, but it is certain that at the present day the market of Madrid is supplied with a species of crayfish from the neighborhood of that city. "The crayfish appears to be unknown in the rivers Douro and Tagus on the western side of the Peninsula, and in the Ebro on the eastern; but it is found abundantly in the Talegones and Escalote, rivulets forming part of the sources of the Douro, in the Henares, one of the sources of the Tagus, and in the upper part of the Jalon, an important tributary of the Ebro. Widely separated, however, as these three rivers become in their courses to the sea, both east and west, the rivulets I have mentioned as forming their principal sources all take their rise within an area probably not more than twenty miles square, situated nearly in the centre of Spain, and about forty or fifty miles northeast of Madrid. It is from these small streams that the Madrid market is supplied, ... and these streams are the only ones well within the borders of the Peninsula in which, so far as I can discover, the crayfish is to be found. . . . . The peculiar localization of these crustaceans in the centre of Spain suggests the idea of their having been specially introduced, but experiments in acclimatization are, I believe, unknown in the Peninsula." ‡

Huxley tells us (*op. cit.*, p. 298) that the crayfishes from the neighborhood

* Gerstfeldt's "Steinkrebs" from the Rhone (*op. cit.*, p. 577) is *A. pallipes*.

† In the collection of the Academy of Natural Sciences of Philadelphia are specimens from the Rhine (Dr. Hallowell) and from Paris (Guérin Coll., No. 284).

‡ Note on the Distribution of the Crayfish (Astacus) in Spain. By E. W. H. Holdsworth, F. L. S., F. Z. S., etc. Proc. Zoölog. Soc. London, 1880, pp. 421, 422.

of Madrid are "altogether similar to those of Britain [*A. pallipes*], except that the subrostral spine is less developed."

Crayfishes are also said to be found in the neighborhood of Barcelona, on the eastern coast of Spain (Gerstfeldt, *op. cit.*, p. 587). I cannot find any mention of them in Portugal.

Astacus pallipes also inhabits England and Ireland, in which it is probably the sole species. All the English and Irish specimens seen by Huxley belong to this species (Huxley, *op. cit.*, pp. 288, 298).* Bell's figure is certainly the same, and probably Pennant's as well, although concerning the latter there may be some doubt. According to Huxley, "They are abundant in some of our [English] rivers, such as the Isis and other affluents of the Thames; and they have been observed in those of Devon;† but they appear to be absent from many others. I cannot hear of any, for example, in the Cam or the Ouse, on the east, or in the rivers of Lancashire‡ and Cheshire, on the west. It is still more remarkable, that, according to the best information I can obtain, they are absent in the Severn, though they are plentiful in the Thames and Severn Canal. Dr. M'Intosh, who has paid particular attention to the fauna of Scotland, assures me that crayfish are unknown north of the Tweed."§

Crayfishes are found in many localities in Ireland, where they would seem to have been distributed to a greater or less extent by artificial means.‖ Perhaps they are not indigenous in any part of the island. Some remarks of Wm. Thompson¶ point to the existence of two species in Ireland (*A. fluviatilis* and *A. pallipes*?).

A. pallipes is a burrowing species, being found in the winter, according to Huxley, in holes in the banks of streams. The burrows may be more than a yard deep.** In the neighborhood of Strasburg it is found in holes in the canals (Lereboullet).

* *A. torrentium* of Huxley is *A. pallipes* Lereb.

† Moore, Mag. Nat. Hist., New Series, III. 289, 1839.

‡ There are specimens in the Museum of Comparative Zoölogy, from William Stimpson, said to have come from the neighborhood of Liverpool.

§ Huxley, *op. cit.*, p. 288.

‖ Wm. Thompson, "The Crustacea of Ireland," Ann. Mag. Nat. Hist., XI. 106, 1843.

¶ *Op. cit.*, p. 107, foot-note.

** Huxley, *op. cit.*, p. 8.

8. Astacus fluviatilis.

? *Cammarus*, Belon, De Aquatilibus, p. 353, fig. on p. 355, 1553.

Astacus fluviatilis, Rondelet, Universa Aquatilium Historia, Pars II. p. 210, with cut, 1555.

Astacus fluviatilis, Gesner, Historia Animalium, Lib. IV. p. 120, with cut, 1558. (In part. Edelkrebs, p. 122.)

Cammarus, Mattioli, Commentarii in Sex Libros Dioscoridis de Medica Materia, Lib. II. p. 309, with fig., 1565.

Cammarus, seu Astacus fluviatilis, Aldrovandi, De Reliq. Animal. Exang. : Moll. Crust. Testac. et Zoophyt., Cap. VI. p. 127, with cuts, 1606. (In part. Krebs, Edelkrebs, p. 129.)

Astacus fluviatilis (in part), Schonevelde, Ichthyologia, p. 24, 1624.

Gammarus seu Astacus fluviatilis, Worm, Museum Wormianum, p. 248, 1655.

Cammarus seu Astacus fluviatilis, Jonston, Hist. Nat. de Exang. Aquat., p. 18, Tab. II. fig. 4, Tab. III. figs. 2, 3, 4, Tab. IV. fig. 1 (fig. 2 after Aldrovandi), 1650. Also in Ruysch, Theatrum Univ. Animal., Pars IV. p. 15, Tab. II. fig. 4, Tab. III. figs. 2, 3, 4, Tab. IV. figs. 1, 2, 1718.

Gammarus seu Cancer fluviatilis, Sachs à Lowenheimb, Γαμμαρολογία, p. 204, Tab. VIII. (after Jonston), 1665.

Cancer macrourus; rostro supra serrato, basi utrinque dente simplici, Linné, Fauna Suecica, p. 358, 1746.

Der Flusskrebs, Rösel, Insekten-Belustigung, Th. III. p. 305, Tab. LIV.–LXI., 1755. (Figs. copied in Encycl. Méth., Vol. CXCI., Pl. 286, 288, 289, 290, 1830.)

Cancer astacus, Linné, Syst. Nat., 10th ed., I. 631, 1758; 12th ed., I. 1051, 1767.

Astacus fluviatilis, Fabricius, Syst. Entomol., p. 413, 1775. — Species Insectorum, I. 509, 1781. — Mantissa Insectorum, I. 331, 1787. — Entomol. Syst. emend. et aucta, II. 478, 1793. — Suppl. Entomol. Syst., p. 406, 1798.

Astacus fluviatilis, De Geer, Mém. pour serv. à l'Hist. des Insectes, Tom. VII., Pl. XX. — XXII., 1778.

Cancer astacus, Bock, Versuch einer wirthschaftlichen Naturgesch. von dem Königreich Ost- und West-preussen, V. 278, 1785.

Cancer astacus, Herbst, Versuch einer Naturgeschichte der Krabben und Krebse, II. 38, Tab. XXIII. fig. 9, 1796. (In part. Edle Krebse, p. 41.)

Astacus fluviatilis, Latreille, Hist. Nat. gén. et partic. des Crustacés et des Insectes, I. 367, Pl. III., 1801; III. 33, 1801; V. 235, 1802. — Gen. Crust. et Insect., I. 51. 1806.

Astacus fluviatilis, Bosc, Hist. Nat. Crust., II. 62, Pl. XI. fig. 2, 1802.

Cancer nobilis (Edelkrebs), Schrank, Fauna Boica, III. 246, 1803.

Edelkrebs, Wolf, Mag. neuest. Zustand Naturkunde, Bd. XI., Taf. I. fig. 3, 1806.

Astacus fluviatilis, Lamarck, Hist. Nat. Anim. sans Vertèbres, V. 216, 1818.

Astacus fluviatilis, Desmarest, Consid. Gén. sur la Classe des Crustacés, p. 211, 1825.

Astacus fluviatilis, Brandt and Ratzeburg, Medizinische Zoologie, II. 58, Tab. X., XI., 1833.

Astacus fluviatilis (in part), Milne Edwards, Hist. Nat. Crust., II. 330, 1837. (Second "variety" noted on p. 331.)

Astacus fluviatilis, Koch, Deutschlands Crustaceen, Myriapoden und Arachniden, Heft 36, No. 23, with fig. (Panzer and Herrich-Schäffer's Deutschlands Insecten, Heft 186, No. 23), 1841.

Astacus fluviatilis, Erichson, Arch. Naturgesch., XII. Jahrg., I. 90, 1846.

Astacus fluviatilis, Lereboullet, Mém. Soc. Sci. Nat. Strasbourg, Tom. V., Pl. III. figs. 1–1d, 1858.

Astacus fluviatilis communis, Gerstfeldt, Mém. Acad. Impér. Sci. St. Pétersbourg, IX. 554, 584, 1859.

Astacus fluviatilis, Heller, Die Crustaceen des südlichen Europa, p. 214, Taf. VII. fig. 4, 1863.

Astacus fluviatilis (l'écrevisse à pieds rouges), Carbonnier, L'Écrevisse, p. 8, 1869.

Astacus fluviatilis, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 257 [357], 1874.

Astacus nobilis,* Huxley, The Crayfish, pp. 295, 296, fig. 61, B, E, H, fig. 62, B, E, 1880.

Astacus fluviatilis (Edelkrebs), Klunzinger, Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg, XXXVIII. Jahrg., p. 342, 1882.

Astacus fluviatilis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 155, 1884.

Remarks on the Synonymy.—The above list comprises only the more important systematic works relating to *Astacus fluviatilis*. Works devoted exclusively to its anatomy, development, and physiology have been purposely omitted.

* See foot-note on page 143.

Under the name of *Astacus fluviatilis*, *Cammarus*, or *Gammarus*, the older authors included not only the "Edelkrebs," or the species to which the name *A. fluviatilis* is now restricted, but also the "Steinkrebs," or "Thulkrebs," a smaller form now known as *A. torrentium*. Indeed, it is probable that these authors confounded *A. torrentium* and *A. pallipes* under the one name "Steinkrebs."* As early as 1558 Gesner wrote: "Abundant Astaci fluviatiles in Helveticis et alpinis regionibus, in rivis, fluviis, torrentibus, lacubus. Sunt autem duorum generum: alii nobiles cognominantur (Edelkrebs), majores nigriorescque: alii Steinkrebs (id est saxatiles) et Thulkrebs (nescio unde dicuntur) reperiuntur in rivis saxosis, minores, parte supina albiores, prona nigriores; elixi non undiquaque rubescunt, sed partim albicant."†

Herbst (1796), in his account of *Cancer astacus*, not only discriminates between the Edelkrebs and the Steinkrebs, but mentions the large crayfish from the Volga and the Jaik, afterwards described as a distinct species by Eschscholtz under the name of *A. leptodactylus*.‡

In 1802 Schrank first separated the Steinkrebs and Edelkrebs as two distinct species, *Cancer torrentium* and *C. nobilis* (Fauna Boica, p. 246). The Russian *A. leptodactylus* was first named and described as a distinct species in 1823, by Eschscholtz (Mém. Soc. Impér. Nat. Moscou, Tom. V. p. 109, Tab. XVIII.). Fourteen years later, Milne Edwards, in the second volume of his classical "Histoire Naturelle des Crustacés," describes but one species of European Astacus (*A. fluviatilis*). He says, however: "Il existe deux variétés de cette écrevisse: dans l'une, le rostre se rétrécit graduellement dès sa base, et ses dents latérales sont situées près de son extrémité; dans l'autre, les bords latéraux du rostre sont parallèles dans leur moitié postérieure, et les dents latérales sont plus fortes et plus éloignées de son extrémité." The second so-called "variety" is *A. fluviatilis*. The first might be either *A. torrentium* or *A. pallipes*, for anything in the description, but the figure given by him in the Disciples' edition of Cuvier's Règne Animal is *A. pallipes*, which seems to be commoner in France than *A. torrentium*.

* The figures of the European crayfish in the older writers down to Pennant, as far as they can be determined, seem to represent *A. fluviatilis sensu strictiori*. Pennant's "Crawfish" is apparently *A. pallipes*. Of the figures published in the sixteenth and seventeenth centuries, those of Gesner and Mattioli, and Jonston's Tab. III. figs. 2, 3, 4, are tolerably good representations of the species.

† *Op. supra cit.*, p. 122. Cf. Aldrovandi, Schonevelde, Rösel, *ll. c.*, etc.

‡ So also Bose, *op cit.*, p. 38 (2d ed.): "Dans les grands fleuves de la Russie asiatique, tels que le Don, le Volga, etc., il y a des écrevisses d'une prodigieuse grandeur, qu'on ne pêche que pour avoir leurs pierres"; and on p. 40, under *Astacus fluviatilis*, "Se trouve dans les rivières en Europe *et en Asie*." So also Desmarest, *op. cit.*, p. 211, 1825.

In 1858 Lereboullet clearly pointed out the differences between the three species of Astacus inhabiting Western and Central Europe, viz. *A. fluviatilis*, *A. pallipes* (Dohlenkrebs), and *A. longicornis* (Steinkrebs). Lereboullet's *A. longicornis* is the species previously described by Schrank as *Cancer torrentium*.

In 1859 there was published a revision of the European Astaci by Gerstfeldt,* based chiefly upon the material in the Museum of the Imperial Academy of Sciences of St. Petersburg, and in the collection of the University of Dorpat. Gerstfeldt concludes that there are only two species of Astacus in Europe: *A. fluviatilis* (including four varieties, *A. fluviatilis communis*, *A. leptodactylus* Eschscholtz, *A. angulosus* Rathke, and *A. pachypus* Rathke) and *A. torrentium*, the "Steinkrebs." No one will deny that *A. fluviatilis*, *leptodactylus*, and *pachypus* are closely related to each other, but, judging from the material which I have examined, they constitute three species. It is true that some specimens of *A. fluviatilis* vary slightly in the direction of *A. leptodactylus*,† and *vice versa*, but not to such a degree as to bridge over the chasm between the two forms, or to puzzle even an untrained eye in separating them. I agree with Kessler in considering *A. fluviatilis*, *leptodactylus*, and *pachypus* to be distinct species.‡ *A. angulosus*, on the other hand, appears to pass by transitional forms into *A. leptodactylus*, and may be considered a local variety of the latter. Gerstfeldt's knowledge of the "Steinkrebs" was limited to five poorly preserved specimens from the Rhone River, which his description on page 577 shows to have been *A. pallipes* Lereb. He confounds this form with another species, the *Cancer torrentium* of Schrank.

Distribution. — Owing to the lack of discrimination on the part of most authors between the three species *A. fluviatilis*, *pallipes*, and *torrentium*, it is impossible accurately to determine the geographical range of these common European crayfishes, and the problem is further complicated by the artificial introduction of these animals as a food supply into many rivers to which they are not indigenous. *A. fluviatilis* alone among them is found within the limits of the Russian Empire. "Here it inhabits especially the Baltic watershed, where it reaches the northern as well as the eastern limit of its dis-

* Ueber die Flusskrebse Europa's. Von G. Gerstfeldt. Mém. Acad. Impér. Sci. St. Pétersbourg, Tom. IX.

† For example, in some specimens of *A. fluviatilis* the margins of the rostrum are slightly denticulate, and the fingers are longer than in the ordinary specimens.

‡ Kessler (*op. cit.*, p. 368) points out the fact, that in the Baltic area, where *A. leptodactylus* has invaded the domain of *A. fluviatilis*, no intercrossing of the two forms has taken place, but the former is driving out the latter.

tribution. Its extension in Finland, according to Nylander,* is bounded by a line passing from Christinestad, on the Gulf of Bothnia, southeasterly to Serdobol, at the northern end of Lake Ladoga. Eastward from Lake Ladoga it is found in the Uslanka, a tributary of the Sveer. It seems to be the sole occupant of the waters which flow from the south into the Gulf of Finland and the Baltic Sea, excepting the streams and lakes that are connected by means of canals with the basin of the Volga. In these it is partially replaced by *A. leptodactylus*. It still holds its own in Lakes Beresai and Bologoe, and in the small tributaries of the Msta and the Volkhov. Finally, it is found in some of the small streams of the upper part of the basin of the Dnieper as far as Mohecley."† According to Gerstfeldt (*op. cit.*, p. 558), *A. fluviatilis* sometimes passes out from the mouths of rivers into the sea, having been captured with marine fishes at a considerable distance from the shore on the coast of Livonia.

To the westward, *A. fluviatilis* extends into Austria, Germany, and France, dividing the field with *A. torrentium* and *A. pallipes*. It is difficult to determine its southern limits from the literature, on account of the uncertainty of the identification. If Scopoli's *Cancer astacus*‡ be this form, it is plentiful in Lake Kirknitz in Carniola. Belon (*op. cit.*, p. 353) speaks of crayfishes in the Po, and Olivi (Zoologia Adriatica, p. 48, 1792) gives "*Cancer astacus*" as one of the animals found in the neighborhood of Venice. Risso (Hist. Nat. Eur. Mérid., Tom. V. p. 55, 1826) records *A. fluviatilis* from the river Taggia, province of Porto Maurizio, and Costa includes it in his catalogue of the Crustacea of the kingdom of Naples (Fauna del Regno di Napoli, 1840). Heller, who distinguishes between *A. fluviatilis* and *A. pallipes*, gives as localities for the former, Nice, the Po, and Naples. Perhaps these localities are simply given on the authority of the older authors just enumerated; in which case, I suspect that the Italian crayfishes may turn out to be the

* Notzer ur Sällskap. pro Fauna et Flora Fennica. Förhandl. Ny Ser., Heft I. p. 248, 1859.

† Kessler, *op. cit.*, pp. 259, 260 [359, 360]. Gerstfeldt (*op. cit.*, p. 588) reports *A. fluviatilis* from Moscow, but perhaps it was brought there artificially for food, as it is more highly esteemed in this regard than its relative, *A. leptodactylus*. According to the same authority, there are two specimens of *A. fluviatilis* in the collection of Dorpat University, labelled *A. pachypus*, from Nicolaiev in Southern Russia (Boug River). It was formerly found in the Government of Koorsk (native or introduced?). See Köppen, Beitr. Kenntn. Russ. Reiches, 2te Folge, Bd. VI. pp. 297, 298. It was introduced into Southern Finland in the time of John III. of Sweden (1568–92). Middendorff, Sibirische Reise, Bd. IV. Th. 2, pp. 885, 886; Köppen, *op. cit.*, p. 297.

‡ Entomologia Carniolica, 1763. Cf. Gerstfeldt, *op. cit.*, p. 585, who thinks that the large specimens recorded from the river Kerka at Gurk may be *A. leptodactylus*. Heller, *op. cit.*, p. 215, also gives these Carniolian localities for *A. fluviatilis*, but whether from his own knowledge or on the authority of the older authors I cannot say.

commoner Southern species *A. pallipes*, which has been very generally confounded with *A. fluviatilis*.

The Astaci from the Spanish peninsula are probably *A. pallipes*, as well as those of England and Ireland.*

A. fluviatilis is also found in Denmark (Huxley, *op. cit.*, p. 299) and in the Scandinavian peninsula. It appears to have been introduced artificially into the latter, having been scarcely known in Sweden before the time of John III. (1568–92).† From Sweden it has spread into Southeastern Norway.‡

9. Astacus leptodactylus.

Astacus leptodactylus, Eschscholtz, Mém. Soc. Impér. Nat. Moscou, VI. 109, Tab. XVIII., 1823.
Astacus leptodactylus, Rathke, Mém. Acad. Impér. des Sci. St. Pétersbourg, III. 359, Tab. IV. figs. 1, 2, 1837. (Separate, 1836.)
Astacus leptodactylus, var. *Caspia*, Eichwald, Bull. Soc. Impér. Nat. Moscou, 1838, p. 148. — Fauna Caspio-Caucasia, p. 179, Tab. XXXVI. fig. I, 1841.
Astacus leptodactylus, var. *salinus*, Nordmann, Observations sur la Faune Pontique, in Demidoff's Voyage dans la Russie Mérid. et la Crimée, Atlas, Crustacea, Tab. 1. (No date.§)
Astacus leptodactylus, Erichson, Arch. Naturgesch., XII. Jahrg., I. 90, 1846.
Astacus fluviatilis, var. *leptodactylus*, Gerstfeldt, Mém. Acad. Impér. des Sci. St. Pétersbourg, IX. 558, 584, 1859.
Astacus leptodactylus, Heller, Die Crustaceen des südlichen Europa, p. 215, Taf. VII. fig. 6, 1863.
Astacus leptodactylus, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 249 [349], 1874.
Astacus leptodactylus, Huxley, The Crayfish, p. 303, fig. 75 (after Rathke), 1880.
Astacus leptodactylus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 157, 1884.

Var. angulosa.

Astacus angulosus, Rathke, Mém. Acad. Impér. des Sci. St. Pétersbourg, III. 364, Tab. IV. fig. 3, 1837. (Separate, 1836.)
Astacus angulosus, Erichson, Arch. Naturgesch., XII. Jahrg., I. 91, 1846. (After Rathke.)
Astacus fluviatilis, var. *angulosus*, Gerstfeldt, Mém. Acad. Impér. des Sci. St. Pétersbourg, IX. 563, 584, 1859.
Astacus angulosus, Heller, Die Crustaceen des südlichen Europa, p. 216, 1863.
Astacus leptodactylus, var. *angulosus*, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 251 [351], 1874.
Astacus leptodactylus, var. *angulosa*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 157, 1884.

Distribution. — *Astacus leptodactylus* has the widest distribution of any of the European species of Astacus. It is found in all the rivers that flow into the Black Sea and the Sea of Azov on the north from the Danube to Mount Caucasus, and in those that empty into the Caspian Sea as far east as the Ural Mountains and the Muchojar Hills in Western Siberia. It descends into the brackish waters of the estuaries of the rivers that empty into the Black

* See pp. 144, 145.
† Linné, Fauna Succica, p. 358, 1746.
‡ G. O. Sars, Hist. Nat. des Crustacés d'Eau douce de Norvège, p. 11, 1867.
§ The text is dated 1840.

Sea and the Sea of Azov, and it is widely distributed in the Caspian Sea, having been reported from the following points therein: Peninsula of Manghishlak, Island of Cheleken, Krasnovodsk, Astrabad, Sara Island, Lenkoran, and Bakoo (Kessler, Eichwald). It has been taken with the dredge from a depth of six to nineteen fathoms in the Caspian Sea (Kessler, p. 372). I have seen specimens from the basin of the Danube as far up as Balaton Lake * in Hungary (Coll. Peabody Mus. Yale Coll.), and Heller reports it from the Theiss River and Mohacs. Middendorff states that it ascends the Volga system to the sixtieth parallel, in the neighborhood of Tcherdy.† It is also found to the northward in the rivers and lakes which drain into the Baltic and White Seas, Erichson reporting it from Courland,‡ Kessler from many of the lakes and rivers that connect with the Gulf of Finland; viz. Lakes Ilmen and Valdai, and the rivers Vodla, Vytegra, Sveer, Volkhov, and Msta.§ Here it has invaded the domain of *A. fluviatilis*, and according to Kessler is supplanting that less fertile species.‖ In the Northern Dwina *A. leptodactylus* alone is found, descending to Archangel.**

The Ponto-Caspian basin is undoubtedly the original home of *A. leptodactylus*. Thence its migration into the northern rivers was made easy by the canals connecting the Volga and Dnieper with the rivers of the Baltic and White Seas.

A. leptodactylus was introduced by man in 1822 into the River Isset, a tributary of the Tobol, in Western Siberia, and is now common in many of the streams of the Obi River basin, e. g. the Toora, Niza, Irtish, Tara, Om, and also in the upper part of the Obi. Its distribution over such a wide area of the Obi basin is due partly to spontaneous spreading, partly to artificial transference from one stream to another. It is probable that crayfishes did not exist in the waters east of the Ural Mountains until they were transported thither by man, although Pallas †† speaks of their presence in the upper course of the Ui, an affluent of the Tobol, as early as 1770. As the

* The water of Balaton Lake is said to be slightly salt.

† Sibirische Reise, Bd. IV. Th. 2, p. 882, 1867.

‡ Kessler (*op. cit.* p. 253 [353]) doubts whether *A. leptodactylus* be found in Courland, as Erichson announced; but as the Southern Dwina is connected by means of canals with both Lake Ilmen and the Beresina River (an affluent of the Dnieper), immigration of this species into Courland would be facilitated.

§ The Msta, which flows into Lake Ilmen, and thence through Lake Ladoga into the Gulf of Finland, is connected by a canal with the Tvertsa, a tributary of the Volga. The Vytegra also communicates with the basin of the Volga through the Mariuskoi Canal.

‖ According to Kessler *A. leptodactylus* lays from 500 to 600 eggs, *A. fluviatilis* rarely more than 250.

** *A. leptodactylus* is also found in Lapland, according to Gerstfeldt, *op. cit.*, p. 589.

†† Reise durch verschiedene Provinzen des Russischen Reiches, Th. II. p. 381.

sources of the Ural River are not remote from those of the Ui, it is possible that a spontaneous migration from the former into the latter has taken place.*

Eichwald describes and figures *A. leptodactylus*, var. *Caspia*, from the Caspian Sea near Lenkoran, as smaller than the normal form, the carapace smoother, and the margins of the rostrum nearly smooth. It is probably an immature stage of *A. leptodactylus*.

In *Astacus angulosus* Rathke, from the Crimea and adjacent region, the fingers of the male are not elongated, as in *Astacus leptodactylus* Eschscholtz, so that the hand has much the same form as in the female of the latter species. The rostrum, moreover, is broader, with its margins more nearly parallel from the base to the lateral spines, and with its median carina prominent and toothed toward the apex; the abdominal pleura are shorter and broader than in *A. leptodactylus*. The flattening of the sides of the carapace, by which an angle is formed by the dorsal and lateral faces, is not characteristic of this form, although it suggested the name to Rathke. The same condition is sometimes found in specimens that in all other respects agree with the form *leptodactylus*, while in some examples of *A. angulosus* the branchial regions are as convex as in *A. leptodactylus*. In the shape of the rostrum and abdominal pleura *A. angulosus* approaches *A. fluviatilis*, but it cannot be confused with that species, on account of the shape of the chela, the double pair of post-orbital spines, etc. Forms intermediate between *A. angulosus* and *A. leptodactylus*, having the rostrum of the latter combined with characters belonging to the former, are met with in the Sulak River, which flows into the Caspian south of the Terek on the northern side of Mount Caucasus (Gerstfeldt). It seems natural, therefore, to consider *A. angulosus* a variety of *A. leptodactylus*.

Since this account of the European Astaci was written, Wladimir Schimkewitsch† has published an insufficient preliminary notice of an Astacus from the neighborhood of the town of Turkestan in the valley of the Jaxartes. It is closely related to *A. fluviatilis* and *A. leptodactylus*, perhaps not specifically distinct from one of these. It seems to be subject to considerable variation in the form of the rostrum and telson. According to Schimkewitsch it differs from all the allied species in the great development of spiny tubercles on the sides of the carapace (there being four on the hind border of the cervical

* With reference to the presence of *A. leptodactylus* in Western Siberia, see Kessler, *op. cit.*, p. 371, Middendorff, *op. cit.*, p. 885, and especially Köppen, "Notiz über die Rückwanderung der *Dreissena polymorpha* Pall. Nebst einem Anhange: Ueber künstliche Verpflanzung der Flusskrebse in Russland." Beitr. zur Kenntniss des Russischen Reiches, 2te Folge, Bd. VI., 1883.

† Der turkestanische Flusskrebs. (Vorläufige Mittheilung.) Von Wladimir Schimkewitsch. Zoologischer Anzeiger, VII. 339–341, 23 Juni, 1884.

groove on each side of the body) and in the shape of the anterior process of the epistoma, which is triangular with convex sides. It would seem to approach *A. angulosus* in the spiny character of the carapace. Schimkewitsch affirms that intermediate forms connect *A. pachypus* with *A. leptodactylus* (Government of Riazan), and *A. leptodactylus* with *A. fluviatilis* (Governments of Toola and Moscow). He evidently inclines, with Gerstfeldt, to the opinion that all the Eurasiatic Astaci, excepting those of the Amoor basin and Japan, form but two distinct species, viz. *A. nobilis* (including the varieties *A. fluviatilis, leptodactylus, angulosus, pachypus, Colchicus,* etc.) and *A. torrentium* (including *A. pallipes*) of Western Europe. In the material that has fallen into my hands I have not seen indications of the intermediate forms, and I have been led to consider all the forms just named to be valid species, with the exception of *A. angulosus*. Kessler, who had unrivalled opportunities for forming a just opinion on this point, came to the same conclusion. After all, to any one who believes that all these forms are descended from a common ancestor, the question whether they constitute two species with marked varieties, or whether they rather form two groups of closely allied species, is merely a question of terms.

10. Astacus pachypus.

Astacus pachypus, Rathke, Mém. Acad. Impér. Sci. St. Pétersbourg, III. 365, 1837. (Separate, 1836.)
Astacus Caspius, Eichwald, Bull. Soc. Impér. Nat. Moscou, 1838, p. 149. — Fauna Caspio-Caucasia, p. 181, Tab. XXXVI. fig. 2, 1841.
Astacus pachypus, Erichson, Arch. Naturgesch., XII. Jahrg., I. 91, 1846. (After Rathke.)
Astacus Caspius, Erichson, *op. cit.*, p. 92, 1846. (After Eichwald.)
Astacus fluviatilis, var. *pachypus et Caspius*, Gerstfeldt, Mém. Acad. Impér. Sci. St. Pétersbourg, IX. 566, 584, 1859.
Astacus pachypus, Heller, Die Crustaceen des südlichen Europa, p. 217, 1863.
Astacus pachypus, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 254 [354], 1874.
Astacus pachypus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 158, 1884.

Distribution. — Brackish waters of the Caspian Sea and estuaries of rivers flowing into the Caspian and Black Seas. Estuary of the Dniester at Kologlea (Kessler); of the Boug at Nicolaiev (Rathke, Kessler); mouths of the Volga, Astrakhan (Kessler); Lesser Oozen River; Caspian Sea at Manghishlak (Kessler), Krasnovodsk (Kessler), and Bakoo.

11. Astacus Colchicus.

Astacus Colchicus, Kessler, Bull. Soc. Impér. Nat. Moscou, L. 2, 1876.
Astacus Colchicus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 158, 1884.

Distribution. — Upper part of Rion River and tributaries, Transcaucasia. According to Kessler, Astaci are found in Lake Palæostom, south of the mouth of the Rion; but whether they be *A. Colchicus* or not is unknown. *A. Colchicus* is brought to the market of Tiflis from the upper Rion. It has

been artificially introduced, according to Dr. Radde, into some of the tributaries of the upper Koor (the Cyrus of the ancients), which flows eastward into the Caspian Sea (Kessler).

NOTE ON THE FOSSIL ASTACIDÆ.

Abundant fossil remains of Crustacea nearly allied to the recent Homaridæ and Astacidæ are found in the Jurassic from the Middle Lias to the lithographic slates of Bavaria and Würtemberg. These ancient Decapods, belonging to the genera Eryma and Pseudastacus,* agreed with the lobsters and crayfishes of the present day in having the three anterior pairs of legs terminated by pincer-like claws (the first pair large and powerful), the abdominal pleura drawn out into prominent lateral plates, and the outer branch of the enlarged posterior pair of appendages or swimmerets divided by a transverse suture. The carapace was produced into a prominent rostrum, commonly denticulate on the margin; the telson showed no trace of a division into two pieces by a transverse suture (agreeing in this regard with the telson of the modern Homaridæ and Parastacinæ), and was more triangular in outline than in the living forms; the large chelæ were nearly symmetrical on the two sides of the body, and the shell granulated or tuberculated, as in the Astacidæ. If we unite the Homaridæ and the Astacidæ in one tribe, the Astacoidea, there can be no reasonable doubt that the Jurassic genera Eryma and Pseudastacus would be included properly in this tribe. To them we turn in seeking the progenitors of the Homaridæ and Astacidæ of our seas and rivers. Unfortunately, these fossils have imparted as yet no information concerning certain important structural features which must be known before we can determine whether the Astacine type was thus early differentiated from the Homarine. I refer to the number, structure, and arrangement of the gills; the condition of the last thoracic somite, whether free or fixed; and the structure of the anterior abdominal appendages. In our ignorance of these structural characters in these marine Jurassic fossils I cannot see the slightest ground for Huxley's conclusion, that in the genus Pseudastacus we already see a differentiation of the Astacine from the Homarine type represented by Eryma.† Pseudastacus differs from Eryma in having a longer rostrum, longer and thicker antennal peduncle and scale, and in the lack of movable spines on the penultimate segment of the fourth pair of legs. In *P. pustulosus* (Münst.) the inner as well as the outer branch of the swimmerets seems to have been divided by a transverse suture. Now, in none of these particulars does Pseudastacus, as distinguished from Eryma, approach the Astacidæ of the present time. Boas‡ has called attention to the fact that the transverse part of the "cervical" groove of Pseudastacus is the same as the anterior and more deeply impressed groove (marked *c'* in Boas's figures) on the carapace of Eryma, and that it is not homologous with the cervical groove of Homarus and Astacus (*c* of Boas's figures), but rather with the anterior slightly impressed groove seen on the carapace of Nephrops.

* For an account of these animals, the reader is referred to the beautifully illustrated work of Oppel, Palaeontologische Mittheilungen, Stuttgart, 1862. The *Astacus Knorrii* of Milne Edwards (Hist. Nat. Crust., II. 333), figured by Knorr and by Desmarest, is probably an Eryma.

† Huxley, The Crayfish, p. 343.

‡ Studier over Decapodernes Slægtskabsforhold. Vidensk. Selsk. Skr., 6te Række, Naturvid. og Math. Afd., Bd. I. pp. 74, 176, foot-note 2, 1880.

No remains of Crustacea near the Astacidæ have been found in the Wealden, which is of fresh-water origin, while the Cretaceous has yielded the genera Hoploparia and Enoploclytia, which closely resemble the recent Homaridæ. Hoploparia is found also in the London Clay (Eocene).

Schlüter* has described, under the name *Astacus politus*, a Decapod from the Lower Chalk of Westphalia, in which the telson is divided by a transverse suture, as in the majority of the Potamobiinæ; but the single specimen obtained is too imperfect to admit of being definitely placed, the fore part of the carapace, including the rostrum, as well as the terminal portion of all the legs, being lost.†

It is only in the fresh-water Tertiary deposits of the Western United States that fossils have been discovered which can be referred reasonably to the family Astacidæ. Packard‡ has described and figured by the name of *Cambarus primævus* two specimens from the Lower Tertiary beds (Eocene?) of the Bear River Valley in Western Wyoming. Judging from Packard's figures, I should think that these specimens belonged to Astacus rather than to Cambarus. The shape of the antennal scale and the chelæ indicate this. I fail to see the close resemblance pointed out by Packard between these specimens and *Cambarus affinis*. The rostrum, as shown in the figures, resembles that of *A. Dauricus* as nearly as any living form. With reference to the conditions under which these crayfishes lived, Dr. Packard says: "The soft, fine, fissile, clayey shales of the Bear River Tertiaries contain not only a good many herring-like fish, but also genuine skates. The presence of land plants mingled with marine animals shows that the waters were fresh, but communicated with the sea; the conditions were apparently those of a deep estuary, into which fresh-water streams ran, and in these rivers lived the crayfish. The deposits were probably Eocene, if these divisions are to be retained for the Tertiary deposits of the West, and may have been laid down nearer the ocean than those of Green River."

In 1870 Cope§ described three extinct species of Astacus from fresh-water Tertiary deposits in the Territory of Idaho. The specimens were obtained by Clarence King, on the expedition sent out for the geological exploration of the fortieth parallel west of the Mississippi River. I have not been able to find the specimens in the Smithsonian Institution, where they belong.

The first species described by Cope is named *Astacus subgrundialis*. In this form the rostrum is narrow, concave above, acute, with five spinous points on each side and a terminal recurved spinelet; two post-orbital tubercles on each side, the anterior pair spiniform; surface of the carapace smooth or obsoletely wrinkled; abdominal pleura prominent and acuminate, those of the second segment four times as wide as the others; chelæ nearly smooth, not granulate, the superior edge spiniferous; the longitudinal groove of the carpus is well marked, and this segment is not spiniferous; the antennal scales are large, and extend nearly to the tip of the rostrum; areola of moderate width. Length to cervical

* Neue Fische und Krebse aus der Kreide von Westphalen. Von Dr. W. von der Marck und Dr. Cl. Schlüter. Palæontographica, XV. 302, Taf. XLIV. figs. 4, 5, 1868.

† So also with the genus Astacodes founded by Bell (Mon. Foss. Malacostr. Crust. Great Britain, Pt. II. Crust. of the Gault and Greensand, p. 30, Pl. IX. figs. 1–6, 1862) for the reception of *Meyeria falcifer* Phillips from the Speeton Clay.

‡ "Fossil Crawfish from the Tertiaries of Wyoming," Amer. Nat., XIV. 222, 223, March, 1880. "On a Crayfish from the Lower Tertiary Beds of Western Wyoming," Bull. U. S. Geolog. and Geograph. Surv. Terr., VI. 391–397, with two cuts, September, 1881.

§ "On Three Extinct Astaci from the Fresh-water Tertiary of Idaho," Proc. Amer. Philosoph. Soc., XI. 605–607, 1870.

groove, .0415 m.; of rostrum, .0182 m.; of abdomen, .072 m. From near Hot Spring Mountain.

The second species is named *Astacus chenoderma*. "This species is represented by the cheles of opposite sides of one individual, with which I associate with great probability one from the right side of a second. Part of a cephalothorax of a third is associated, but without conclusive evidence of identity, chiefly because of a near resemblance in the sculpture." The chelæ are long and slender, without spinous armature, but covered with thickly set granular tubercles. In the second specimen part of the carpus is preserved; its lower margin is unarmed, while the outer face presents a series of short, distantly placed spines. The surface of the carapace, as seen in the third specimen, is delicately wrinkled by the confluent bases of fine pointed granules, which are directed forward; these become more scattered on the sides. As in *A. subgrundialis*, there are two pairs of post-orbital spines. The areola is of moderate width. Length from rostrum to cervical groove, .0235 m. Width of areola .25 inch from front, .007 m. Length of chela, .045 m. Width of base of chela, .0173 m. From Catharine's Creek.

The third species, *Astacus breviforceps*, is "established primarily on three cheles or last segments of the fore limbs; with these I have associated a cephalothorax of one, and abdominal and postabdominal regions of three individuals. The only reason for such reference of the latter is their superficial texture, in which they resemble the cheles, and differ from the corresponding parts in the two other species." The chelæ are short, thick, the lower edge thin, the index rather short and conical; the surface of the chelæ is granular tuberculate, except on the convex faces, where it is finely vermiculate rugose. "The cephalothorax associated is quite similar to that of *A. subgrundialis*, and may possibly belong to it. It however differs in the finely vermiculate rugose character of its surface. The rugæ are generally transverse on the back and sides." The upper surface of the abbominal segments is marked with a delicate vermiculate rugosity, like that of the cephalothorax. In *A. subgrundialis* it is marked with impressed dots. The pleura of the second abdominal somite are less than twice the width of the succeeding ones, instead of being four times as wide, as in *A. subgrundialis*. The succeeding pleura are long, pointed, and slightly curved forward. "Some of the specimens indicate individuals larger than those referred to *A. subgrundialis*." From Catharine's Creek.

According to Professor Cope, the beds in which these fossils were found are of freshwater lacustrine origin, as determined by the fishes and mollusks found therein. As to their age, there is "great probability of their being later than the Miocene, and nothing to conflict with their determination as of Pliocene age."*

Although nothing is known concerning the gills, or the presence or absence of hooks on the legs, I am disposed to regard the fragments described by Cope as remains of true Astaci, on account of certain superficial characters, such as the denticulate rostrum, the post-orbital tubercles, the prominent acuminate abdominal pleura, etc. The only Astacus known to inhabit the Territory of Idaho at the present day is *A. Gambelii*. Cope himself has pointed out the resemblance of the rostrum of *A. subgrundialis* to that of *A. Gambelii*, and I have already shown (p. 131) that in the structure of the gills the last-named species approaches the primitive type more nearly than any other living Astacus. In the elongated, acuminate abdominal pleura, and in the two pairs of post-orbital tubercles, the fossil species more nearly resemble *C. nigrescens*.

* Cope, *ibid.*, p. 547.

Table showing the Geographical Distribution of every Species of Cambarus and Astacus as far as yet ascertained.

Genus CAMBARUS.

Group I.

1. **C. Blandingii.**
   New York.
   New Jersey: Essex Co.; Delaware River and tributaries near Trenton, Mercer Co.
   Maryland: Baltimore Co.; Caroline Co.; Dorchester Co.; St. Mary's Co.; Somerset Co.; Wicomico Co.; Worcester Co.
   Virginia: James River; Lunenburg.
   North Carolina: Tarboro; tributaries of Neuse River, Goldsboro; Kinston; Beaufort; Salmon Creek; Wilmington.
   South Carolina: Camden; Saluda River; Columbia.
   Georgia: Richmond Co.

   Var. **acuta.**
   South Carolina: Charleston; Beaufort.
   Alabama: Mobile; Blount Spring, Blount Co.; Cullman, Cullman Co.; Decatur, Morgan Co.; overflow of Tennessee River, near Bridgeport, Jackson Co.
   Mississippi: tributary of Tombigbee River, Kemper Co.; near Vicksburg.
   Louisiana: Tickfaw; Amite City; New Orleans.
   Tennessee: Memphis.
   Missouri: St. Louis.
   Illinois: Athens; Decatur; Pekin; Normal; Oquawka; Peoria; Lawn Ridge; Evanston.
   Indiana: Wheatland, Knox Co.
   Iowa: West Liberty; Dubuque.
   Wisconsin: Racine; Sauk City.

2. **C. fallax.**
   Florida: St. John's River at Jacksonville, Orange Bluff, Hawkinsville, Horse Landing, Blue Spring, and Lake Jessup; Magnolia; Indian River; Titusville, Brevard Co.

3. **C. Hayi.**
   Mississippi: Macon; Artesia.

4. **C. Clarkii.**
   Texas: between San Antonio and El Paso del Norte; San Antonio: Waller Co.
   Louisiana: New Orleans; Tangipahoa River.
   Mississippi: Ocean Springs, Jackson Co.
   Alabama: Mobile.
   Florida: Pensacola; three miles below Horse Landing, St. John's River.

5. **C. troglodytes.**
   Georgia: Richmond Co.
   South Carolina: Charleston; Oakley; Columbia.

6. **C. maniculatus.**
   Georgia: in ditches in the lower part of the State. (Le Conte.)
7. **C. Lecontei.**
   Alabama: Mobile.
   Georgia: Athens.
8. **C. angustatus.**
   Georgia: lower part of the State. (Le Conte.)
9. **C. pubescens.**
   Georgia: Richmond Co.
10. **C. spiculifer.**
    Georgia: Athens; Milledgeville; Atlanta; Roswell, Cobb Co.; Chattahoochee River, Gainesville; Etowah River.
11. **C. versutus.**
    Alabama: neighborhood of Mobile.
    Florida: Cape Barrancas. (See page 34.)
12. **C. Alleni.**
    Florida: St. John's River, Hawkinsville; Hernando Co. (See page 36.)
13. **C. penicillatus.**
    Georgia.
    ? Mississippi. (See page 37.)
    ? South Carolina: Charleston. (See page 37.)
14. **C. Wiegmanni.**
    Mexico.
15. **C. pellucidus.**
    Kentucky: Mammoth Cave and other caves in Edmonson Co.
    Indiana: Wyandotte Cave; cave in Bradford, Harrison Co.

GROUP II.

16. **C. simulans.**
    Texas: Dallas; east of Canadian River.
    Kansas: Fort Hays.
17. **C. advena.**
    Georgia.
18. **C. Carolinus.**
    South Carolina: Charleston; Greenville? (See page 56.)
19. **C. gracilis.**
    Illinois: Normal; Lawn Ridge; Athens.
    Wisconsin: Racine.
    Iowa: Davenport.
20. **C. Mexicanus.**
    Mexico.
21. **C. Cubensis.**
    Cuba: near Havana.

GROUP III.

22. **C. Bartonii.**
    Dominion of Canada: St. John, New Brunswick; Montreal?
    Maine: Houlton and Maysville, Aroostook Co.; Madison, Somerset Co. (See p. 62.)

Vermont: Burlington, Colchester, and Shelburne, Chittenden Co.

Massachusetts: Grafton, Worcester Co.; Williamstown, Berkshire Co.

New York: Lake Champlain; Ellenburg, Clinton Co.; Westport and Elizabethtown, Essex Co.; Fulton Lakes, Hamilton and Herkimer Cos.; Canton, St. Lawrence Co.; Port Jervis and Newburg, Orange Co.; Fishkill, Duchess Co.; Fallsburg, Sullivan Co.; Sherburne, Chenango Co.; Cazenovia, Madison Co.; Ithaca, Tompkins Co.; Berkshire, Tioga Co.; Genesee River, Rochester, Monroe Co.; Niagara, Niagara Co.; Forestville, Chautauqua Co.

New Jersey: Schooley's Mountain; Orange; Trenton.

Pennsylvania: Bedford and Pattonville, Bedford Co.; Windham, Bradford Co.; Hummelstown, Dauphin Co.; Carlisle, Cumberland Co.; Berwick, Columbia Co.; Bainbridge, Lancaster Co.; Schuylkill River, near Philadelphia; Chester Co.; McKean Co.; Foxburg, Clarion Co.

Maryland: Harford Co.; Howard Co.; Montgomery Co.; Frederick Co.; Washington Co.; Garrett Co.; Alleghany Co.

District of Columbia: Rock Creek, Georgetown.

Virginia: Clarke Co.; Alexandria Co.; Franklin, Southampton Co.; tributaries of Rappahannock River, Stafford Co.; James River; tributaries of James River, Rockbridge Co.; Lunenburg, Lunenburg Co.; Bath Co.; Reed Creek, west of Wytheville, Wythe Co.; Holston River, Smyth Co.

West Virginia: Williamsport, Grant Co.; South Branch of Potomac River; Patterson's Creek; Petroleum, Ritchie Co.; near White Sulphur Springs, Greenbrier Co.; branch of Clinch River, northern base of Clinch Mountains.

North Carolina: Kinston; Newman's Fork, Blue Ridge, McDowell Co.

Ohio: Marietta; Cincinnati; Yellow Springs; Scioto River, Columbus.

Indiana: New Albany; Fall Creek, Indianapolis.

Lake Superior.

Kentucky: Cumberland Gap, Josh Bell Co.; Smoky Creek, Carter Co.; Kentucky River, Little Hickman, Jessamine Co.; Bear Creek, Grayson's Springs, Grayson Co.; Mammoth Cave, Edmonson Co.

Tennessee: Doe River, Carter Co.; Lineville Cave, near Blountsville, Sullivan Co.; Knoxville.

For doubtful localities for *C. Bartonii*, see page 63.

VAR. **robusta.**

Dominion of Canada: Humber River and Don River, Toronto; Indian Creek, Weston, Province of Ontario.

New York: Forestville, Chautauqua Co.; Genesee River, Rochester, Monroe Co.; Sodus, Wayne Co.; tributary of Racket River, near Tupper's Lake, St. Lawrence Co.; Canton, St. Lawrence Co.; Fulton Lakes, Hamilton and Herkimer Cos.; Natural Bridge, Jefferson Co.

Maryland: Montgomery Co.

Virginia: Fredericksburg.

Illinois: Decatur.

23. **C. acuminatus.**

South Carolina: Saluda River.

24. **C. latimanus.**

South Carolina: Columbia; Greenville.

Georgia: Athens; Milledgeville; Roswell.

Alabama: Blount Spring and Cullman, Sand Mountain; Bridgeport. (See page 69.)
Mississippi: Ocean City.
Tennessee: Ashland City, Cheatham Co. (See page 69.)

25. **C. Diogenes.**
New Jersey: Hamilton Township, Mercer Co.
Pennsylvania: Derry Station, Westmoreland Co.
Maryland: Baltimore Co.; St. Mary's Co.; Caroline Co.; Dorchester Co.; Worcester Co.; Garrett Co.
District of Columbia: near Washington.
Virginia: Alexandria Co.; Accomack Co.; Northampton Co.; Fredericksburg, Spottsylvania Co.; Petersburg, Dinwiddie Co.
North Carolina: Wilmington; Kinston.
Ohio: Kelley's Island, Lake Erie.
Indiana: Long Lake, Kendallville, Noble Co.; Mechanicsburg, Henry Co.; Knox Co.
Illinois: Lawn Ridge; Evanston; Belleville; Decatur; Chicago; Abingdon.
Michigan: Detroit.
Wisconsin: tributary of Pecatonica River, Green Co.; Appleton; Racine.
Iowa: Davenport.
Missouri: Carroll Co.; St. Louis.
Kansas: Leavenworth.
Colorado: Clear Lake.
Wyoming: Cheyenne.
Arkansas.
? Kentucky.
? Tennessee.
Mississippi: Monticello, Lawrence Co.
Louisiana: New Orleans.

26. **C. argillicola.**
Dominion of Canada: Toronto, Province of Ontario.
Michigan: Detroit; East Saginaw.
Indiana: New Albany.

27. **C. dubius.**
Virginia: Pennington's Gap, Lee Co.
West Virginia: Cranberry Summit, Preston Co.
Tennessee: Cumberland Gap.

28. **C. Nebrascensis.**
Dakota: Fort Pierre. (Girard.)

29. **C. Uhleri.**
Maryland: Caroline Co.; Dorchester Co.; Talbot Co.; St. Mary's Co.; Wicomico Co.; Somerset Co.; Worcester Co.

30. **C. extraneus.**
Georgia: Etowah River, Rome.
Tennessee: Tennessee River, near border of Georgia.

31. **C. Girardianus.**
Alabama: Cypress Creek, Lauderdale Co.

32. **C Jordani.**
Georgia: Etowah River, Rome.

33. **C. cornutus.**
Kentucky: Green River, near Mammoth Cave.

34. **C. hamulatus.**
Tennessee: Nickajack Cave.

Group IV.

35. **C. medius.**
Missouri: Irondale, Washington Co.

36. **C. immunis.**
New York.
Indiana: White River; Fall Creek, Indianapolis; Long Lake, Kendallville.
Illinois: Aux Plains; Belleville; Lawn Ridge; Normal; Oquawka.
Michigan: Detroit River, Detroit.
Wisconsin: Milwaukee.
Minnesota: Richfield, Hennepin Co.
Iowa: West Liberty.
Missouri: St. Louis.
Kansas: Leavenworth; Ellis.
Wyoming: near Laramie.
Alabama: Huntsville.
Mexico: Orizaba.

Var. **spinirostris.**
Tennessee: Obion Co.

37. **C. Mississippiensis.**
Mississippi: Macon.

38. **C. Palmeri.**
Tennessee: Obion Co.

39. **C. Alabamensis.**
Alabama: Waterloo, Lauderdale Co.

40. **C. compressus.**
Alabama: Lauderdale Co.

41. **C. lancifer.**
Mississippi: Root Pond.

42. **C. affinis.**
New York: Niagara.
New Jersey: Schooley's Mountain and Dover, Morris Co.; Red Bank, Monmouth Co.; Trenton, Mercer Co.; Camden Co.
Pennsylvania: Brandywine Creek; Schuylkill; Reading; Philadelphia; Bristol; Susquehanna River; Bainbridge; Carlisle.
Maryland: Cecil Co.; Harford Co.; Havre de Grace; Baltimore Co.; Anne Arundel Co.; Montgomery Co.; Potomac River, Charles Co.; Williamsport, Washington Co.; Cumberland, Alleghany Co.
District of Columbia: Potomac River, Washington.
Virginia: Potomac River, Gunston, Fairfax Co.
~~? Lake Erie.~~
? Lake Superior.

43. **C. Sloanii.**

Indiana: New Albany.

Kentucky. (Bundy.)

44. **C. propinquus.**

Dominion of Canada: Montreal; Toronto.

New York: Grass River, Black Lake, and Canton, St. Lawrence Co.; Ogdensburg; Lake Ontario; Garrison Creek, Sackett's Harbor; Four-Mile Creek, Oswego; Oneida Lake; Cayuga Lake; Rochester; Niagara; Forestville, Chautauqua Co. All of these localities are in the St. Lawrence River system.

Indiana: Elkhart River, Rome City, Noble Co.; Delphi; Indianapolis; Michigan City; Turman Creek, Sullivan Co.; Clear Creek, Bloomington; White River; Switz City.

Illinois: Freeport, Stephenson Co.; Ogle Co.; Geneva, Kane Co.; Pekin, Tazewell Co.; Normal, McLean Co.; Decatur, Macon Co.; Aux Plains River.

Michigan: St. Clair River; Detroit River; Northville; Huron River, Ann Arbor; Ecorse; Kalamazoo River, Otsego.

Lake Superior.

Wisconsin: tributaries of Pecatonica River, Green Co.; Madison.

Iowa: Davenport; Des Moines River, Ottumwa.

VAR. **Sanbornii.**

Kentucky: Smoky Creek, Carter Co.

Ohio: Oberlin.

VAR. **obscura.**

New York: Genesee River, Rochester.

45. **C. Harrisonii.**

Missouri: Irondale, Washington Co.

46. **C. virilis.**

Dominion of Canada: Lake Winnipeg; Saskatchewan River; Red River of the North; Toronto; Montreal?

Dakota: Red River of the North, near Pembina; Souris or Mouse River.

Minnesota: Lake Superior; Mississippi River; Lake Minnetonka, Minnehaha Creek, Cedar Lake, Bassett's Creek, and Lake Independence, Hennepin Co.

Wisconsin: Appleton; Baraboo River, Ironton; Sauk City; Wisconsin River; Sugar River; Rock River; Jefferson; Milwaukee.

Iowa: Davenport; Burlington; Fort Dodge; Spring Vale; Des Moines River; Bedford.

Nebraska: Omaha.

Wyoming: near Laramie City.

Kansas: Leavenworth; Manhattan; Republican River, N. W. of Fort Riley; Ellis.

Missouri: St. Louis; Osage River; Irondale.

Illinois: Quincy; Lawn Ridge; Decatur; Normal; Pekin; Cairo; Geneva; Stillman's Creek, Marion.

Indiana: Michigan City; Long Lake, Kendallville; Elkhart River, Rome City.

? Tennessee: near Lebanon.

Arkansas: White River, Eureka Springs.

? Alabama: near Bridgeport, Jackson Co. (See page 97.)

Texas.

? New York: Lake George.

47. **C. rusticus.**
Pennsylvania: Pittsburg; Philadelphia Co.?
Ohio: Kelley's Island, Lake Erie; Miami River, Dayton; Yellow Springs; Ohio River, Cincinnati.
Indiana: Ohio River, Madison; White River; Indianapolis.
Illinois: Quincy; Normal.
Kentucky: Kentucky River, Little Hickman; Perryville, Boyle Co.; Salt River.
Tennessee: Cumberland Gap; Lebanon.
Lake Superior.
Wisconsin: Racine; Beloit; Ironton; Fox River.
Iowa: Lizard Creek, Fort Dodge.
Missouri: Osage River.
Arkansas: White River, Eureka Springs.
Texas.

48. **C. spinosus.**
South Carolina: Saluda River.
Georgia: Etowah, Oostenaula, and Coosa Rivers, in the neighborhood of Rome.
Tennessee: Tennessee River, near border of Georgia.
Alabama: Cypress Creek, Lauderdale Co. (See page 117.)

49. **C. Putnami.**
Kentucky: Grayson Springs, Grayson Co.; Green River, near Mammoth Cave.
Tennessee: Cumberland Gap; Knoxville?
? Indiana: Bradford.

50. **C. forceps.**
Alabama: Cypress Creek, Lauderdale Co.
? Tennessee: Knoxville.

Group V.

51. **C. Montezumæ.**
Mexico: neighborhood of City of Mexico; Lake Tezcoco; Puebla; Lake San Roque; Trapuato; Parras, Cohahuila (see page 123); Mazatlan (Pacific Coast).

52. **C. Shufeldtii.**
Louisiana: near New Orleans.

Genus ASTACUS.

1. **A. (Cambaroides) Japonicus.**
Japan: Hakodadi, Yesso.

2. **A. (Cambaroides) Dauricus.**
Siberia: upper portion of the basin of the Amoor River, as far down as Albasin, including the rivers Ingoda, Argoon, Onon, Shilka, and Nercha.

3. **A. (Cambaroides) Schrenckii.**
Siberia: lower portion of the basin of the Amoor River.

4. **A. Klamathensis.**
Dominion of Canada: streams east of the Cascade Mountains, Province of British Columbia.

Washington Territory: upper part of Columbia River and its tributaries at Fort Walla Walla, Wenas Valley, and Spokane Falls.

Oregon: Klamath Lake; Sikan Creek; Des Chutes River.

5. **A. leniusculus.**

Oregon: lower part of the Columbia River.

Washington Territory: lower part of the Columbia River; Puget Sound.

6. **A. Trowbridgii.**

Oregon: Columbia River, near Astoria.

Washington Territory: lower part of the Columbia River; streams running into Shoalwater Bay.

7. **A. nigrescens.**

California: San Francisco; [illegible] San Joaquin [illegible].

Washington Territory: Fort Steilacoom. (See page 135.)

Alaska Territory: Oonalaska.

8. **A. Gambelii.**

Utah: Ogden River, Ogden.

Idaho: Fort Hall; west side of Teton Basin.

Montana: mouth of Yellowstone River.

? Wyoming: Willow Creek. (See page 137.)

? California: Santa Barbara. (See page 137.)

9. **A. torrentium.**

Bohemia, Bavaria, Würtemberg, Alsace.

10. **A. pallipes.**

Greece, Austria, Italy, France, Switzerland, Alsace, Spain, England, Ireland. (See page 144.)

11. **A. fluviatilis.**

Russia (Baltic water-shed and small streams of the upper part of the basin of the Dnieper), Austria, Germany, France, Italy? Denmark (Huxley). Artificially introduced into Sweden, whence it has spread into Southeastern Norway. (See page 148.)

12. **A. leptodactylus.**

Russia (in rivers of the Ponto-Caspian basin, and in rivers and lakes emptying into the Baltic and White Seas), Caspian Sea, Hungary (Danube River basin). Artificially introduced into affluents of Tobol River, Siberia, whence it has spread into the Irtish and Obi.*

VAR. **angulosa.**

Crimea and adjacent region, Russia.

13. **A. pachypus.**

Russia: estuaries of rivers flowing into the Black and Caspian Seas; Malaya Oozen River; Caspian Sea.

14. **A. Colchicus.**

Russia: upper portion of Rion River and tributaries, Transcaucasia. Artificially introduced into some of the tributaries of the upper Koor (ancient Cyrus).

* For the Astacus found in Turkestan, see p. 152.

Table showing our present Knowledge of the Distribution of the North American Species of Cambarus and Astacus, arranged according to States and Territories.

1. MAINE. — One species: *C. Bartonii*, in the St. John, Penobscot, and Kennebec River systems. For detailed localities, see p. 62.
2. NEW HAMPSHIRE. — None.
3. VERMONT. — One species: *C. Bartonii*, in affluents of Lake Champlain, at Burlington, Colchester, and Shelburne, Chittenden Co.
4. MASSACHUSETTS. — One species: *C. Bartonii*, at Williamstown, Berkshire Co., and Grafton, Worcester Co.
5. RHODE ISLAND. — None. According to Prof. E. P. Larkin, Cambari (*C. Bartonii* ?) were common forty years ago at Westerly, in the southwestern part of the State, near the Connecticut line.
6. CONNECTICUT. — None. Prof. S. I. Smith tells me that thirty or forty specimens of *C. Bartonii* were introduced into a brook in New Haven in 1880, but none have been seen there since.
7. NEW YORK. — Five species: *C. Blandingii*, *Bartonii* (including var. *robusta*), *immunis*, *affinis*, and *propinquus* (including var. *obscura*). Perhaps also *C. virilis*.
   C. Blandingii probably comes from the southeastern part of the State.
   C. Bartonii is distributed over the whole of the State.
   C. Bartonii, var. *robusta*, is found in the St. Lawrence River basin in Chautauqua, Monroe, Wayne, St. Lawrence, Hamilton, Herkimer, and Jefferson Counties.
   The particular locality for *C. immunis* is unknown.
   C. affinis comes from Niagara, in the western part of the State, and probably lives also in the southeastern part.
   C. propinquus lives in the waters of the St. Lawrence basin, specimens having been received from Grass River, Black Lake, and Canton, in St. Lawrence Co.; Lake Ontario; Garrison Creek, Sackett's Harbor; Oswego; Oneida Lake; Cayuga Lake, Rochester; Niagara; and Forestville, Chautauqua Co.
   C. propinquus, var. *obscura*, is found in Genesee River, at Rochester.
   C. virilis, Lake George ? (See page 98.)
8. NEW JERSEY. — Four species: *C. Blandingii*, *Bartonii*, *Diogenes*, and *affinis*.
   C. Blandingii is recorded from Essex Co. and from the Delaware River and tributaries in Mercer Co.
   C. Bartonii, from Essex, Morris, and Mercer Counties.
   C. Diogenes, from the Delaware meadows near Trenton, Mercer Co.
   C. affinis, from Morris, Monmouth, Mercer, and Camden Counties.
9. PENNSYLVANIA. — Four species: *C. Bartonii*, *Diogenes*, *affinis*, and *rusticus*. *C. Blandingii*, found on the New Jersey side of the Delaware River, doubtless inhabits the eastern part of the State.
   C. Bartonii is found in Bedford, Bradford, Dauphin, Cumberland, Columbia, Lancaster, Philadelphia, Chester, McKean, and Clarion Counties (Delaware, Susquehanna, and Ohio River systems).
   C. Diogenes, at Derry Station, Westmoreland Co. (Ohio River system).

C. affinis, at Bristol, Philadelphia, Brandywine Creek, Reading, Schuylkill, Bainbridge, and Carlisle (Delaware and Susquehanna River systems).

C. rusticus has been found at Pittsburg, in the western part of the State (Ohio River).

10. Delaware. — None. An exploration of this State will probably discover *C. Blandingii*, *Bartonii*, *Diogenes*, *Uhleri*, and *affinis* within its limits.

11. Maryland. — Five species: *C. Blandingii*, *Bartonii* (including var. *robusta*), *Diogenes*, *Uhleri*, and *affinis*.

Through the investigations of Mr. P. R. Uhler, of Baltimore, the distribution of Cambari in Maryland is well ascertained.

C. Blandingii is found in the counties on Chesapeake Bay and to the eastward, viz. Baltimore, Caroline, Dorchester, St. Mary's, Somerset, Wicomico, and Worcester.

C. Bartonii inhabits the higher regions in the following counties: Harford, Howard, Montgomery, Frederick, Washington, Garrett, and Alleghany.

C. Bartonii, var. *robusta*, has been collected in Montgomery Co.

C. Diogenes inhabits Baltimore, St. Mary's, Caroline, Dorchester, Worcester, and Garrett Counties.

C. Uhleri has been found in Caroline, Dorchester, Talbot, St. Mary's, Somerset, Wicomico, and Worcester Counties.

C. affinis, Cecil, Harford, Baltimore, Anne Arundel, Montgomery, Charles, Washington, and Alleghany Counties.

12. District of Columbia. — Three species: *C. Bartonii*, *Diogenes*, and *affinis*.

13. Virginia. — Seven species: *C. Blandingii*, *Bartonii* (including var. *robusta*), *Diogenes*, *dubius*, *affinis*, *rusticus*, and *Putnami*. *C. Uhleri* will probably be found in Accomack Co.

C. Blandingii has been collected in James River and at Lunenburg.

C. Bartonii appears to be widely distributed in Virginia; the known localities are Clarke Co.; Alexandria Co.; tributaries of Rappahannock River, Stafford Co.; tributaries of James River, Rockbridge Co.; Lunenburg; Franklin, Southampton Co.; Bath Co.; Reed Creek, Wythe Co.; and Holston River, Smyth Co.

C. Bartonii, var. *robusta*, in stony streams running into the Rappahannock and in springs at Fredericksburg, Spottsylvania Co. According to Mr. Uhler, *C. Bartonii*, var. *robusta*, is not found in the tributaries of the Rappahannock in Stafford Co., whence comes the typical *C. Bartonii*.

C. Diogenes, Accomack Co.; Northampton Co.; Fredericksburg, Spottsylvania Co.; Petersburg, Dinwiddie Co.; Alexandria Co.

C. dubius, at one locality, Pennington's Gap, Lee Co., in the southwestern corner of the State.

C. affinis is found in the Potomac River, Fairfax Co.

C. rusticus and *C. Putnami* are found at Cumberland Gap, at the southwestern extremity of the State.

14. West Virginia. — Two species: *C. Bartonii* and *C. dubius*. The former is found in affluents of the Potomac, Grant Co.; Petroleum, Ritchie Co.; White Sulphur Springs, Greenbrier Co.; and in branch of Clinch River, in the southwestern part of the State. The latter (*C. dubius*) comes from Cranberry Summit, Preston Co., in the northern part of the State.

15. North Carolina. — Three species: *C. Blandingii, Bartonii,* and *Diogenes.*

C. Blandingii, from Tarboro; tributaries of Neuse River, at Goldsboro; Kinston; Beaufort; Salmon Creek; and Wilmington. All of these localities are in the eastern part of the State.

C. Bartonii has been found at Kinston, in the eastern part of the State, and in Newman's Fork, in the Blue Ridge Mountains, McDowell Co., in the western part.

C. Diogenes is recorded from Wilmington and Kinston.

16. South Carolina. — Six species: *C. Blandingii* (including var. *acuta*), *troglodytes, Carolinus, acuminatus, latimanus,* and *spinosus.* Perhaps also *C. penicillatus* and *Bartonii.* (See pages 37, 61.)

C. Blandingii comes from Camden, the Saluda River, and Columbia, in the middle region of the State. *C. Blandingii,* var. *acuta,* from Charleston and Beaufort on the sea-coast.

C. troglodytes has been received from Charleston, Oakley, and Columbia.

C. Carolinus, hab. Charleston; Greenville ? (See page 56.)

C. acuminatus, hab. Saluda River.

C. latimanus, hab. Columbia and Greenville.

C. spinosus, hab. Saluda River.

17. Georgia. — Thirteen species: *C. Blandingii, troglodytes, maniculatus, Lecontei, angustatus, pubescens, spiculifer, penicillatus, advena, latimanus, extraneus, Jordani,* and *spinosus.* Perhaps also *C. Bartonii.* (See page 61.)

C. Blandingii and *C. pubescens* come from Richmond Co.

C. troglodytes also comes from Richmond Co. It differs from the typical form of this species. (See page 28.)

C. maniculatus is assigned by Le Conte to the lower part of the State, in ditches.

C. Lecontei has been found at Athens, in the northern part of the State.

C. angustatus comes from the lower regions of the State.

C. spiculifer inhabits the upper part of the State, at Athens; Milledgeville; Atlanta; Roswell, Cobb Co.; Chattahoochee River, Gainesville; Etowah River.

Exact localities for *C. penicillatus* are wanting.

C. advena inhabits Lower Georgia.

C. latimanus is reported from Athens, Milledgeville, and Roswell.

C. extraneus, Jordani, and *spinosus* come from the neighborhood of Rome, in the northwestern part of the State (Etowah, Oostenaula, and Coosa Rivers).

18. Florida. — Four species: *C. fallax, Clarkii, versutus,* and *Alleni.* A species belonging to the *C. Bartonii* group also inhabits Florida.

C. fallax has been collected at the following places: St. John's River at Jacksonville, Orange Bluff, Hawkinsville, Horse Landing, Blue Spring, and Lake Jessup; Magnolia; Indian River; and Titusville, Brevard Co.

C. Clarkii, at Pensacola; and below Horse Landing, on the St. John's River.

C. versutus, at Cape Barrancas (near Pensacola ?).

C. Alleni was discovered at Hawkinsville, on the St. John's River.

19. Alabama. — Eleven species: *C. Blandingii,* var. *acuta, C. Clarkii, Lecontei, versutus, latimanus, Girardianus, immunis, Alabamensis, compressus, spinosus,* and *forceps. C. extraneus* and *C. Jordani* will probably be discovered in the northeastern part of the State, when that territory shall be explored. *C. virilis* is credited to this State with some doubt. (See page 97.)

C. Blandingii, var. *acuta*, at Mobile, in the south, and at Blount Spring, Cullman, Decatur, and Bridgeport, in the north. Decatur and Bridgeport are on the Tennessee River.

C. Clarkii, *Lecontei*, and *versutus* live in the neighborhood of Mobile.

C. latimanus comes from the northern part of the State, from Blount Spring, Cullman, and Bridgeport.

C. Girardianus, *Alabamensis*, *compressus*, *spinosus*, and *forceps* are found in Lauderdale Co., near the Tennessee River, in the northwestern corner of the State.

C. immunis has been collected at Huntsville, Madison Co., in the northern portion of the State.

The larger part of Alabama remains still unexplored.

20. Mississippi. — Seven species: *C. Blandingii*, var. *acuta*, *C. Hayi*, *Clarkii*, *latimanus*, *Diogenes*, *Mississippiensis*, and *lancifer*. Perhaps *C. penicillatus* (see page 37). All the species mentioned above as inhabiting Lauderdale Co., Ala., may be looked for in the northeastern part of Mississippi.

C. Blandingii, var. *acuta*, has been found in a tributary of the Tombigbee River, in Kemper Co., on the eastern border of the State, and near Vicksburg, on the Mississippi River, on the western border.

C. Hayi, from Macon and Artesia, in the western portion of the State.

C. Clarkii and *C. latimanus*, from Ocean Springs, Jackson Co.

C. Diogenes, from Monticello, Lawrence Co.

C. Mississippiensis. Macon.

C. lancifer. The only specimen known up to the present time came from Root Pond, Miss., an unknown locality.

21. Louisiana. — Four species: *C. Blandingii*, var. *acuta*, *C. Clarkii*, *Diogenes*, and *Shufeldtii*.

C. Blandingii, var. *acuta*, has been detected in the neighborhood of New Orleans, Tickfaw, and Amite City.

C. Clarkii, around New Orleans and in the Tangipahoa River.

C. Diogenes and *C. Shufeldtii* come from the neighborhood of New Orleans.

Only a small tract in the southeastern part of this State has been explored.

22. Texas. — Four species: *C. Clarkii*, *simulans*, *virilis*, and *rusticus*.

C. Clarkii. Waller Co.; San Antonio; between San Antonio and El Paso del Norte.

C. simulans. Dallas; "pools east of Canadian River."

The localities of the Texan specimens of *C. virilis* and *C. rusticus* are unknown.

23. Ohio. — Four species: *C. Bartonii*, *C. Diogenes*, *C. propinquus*, var. *Sanbornii*, and *C. rusticus*.

C. Bartonii at Marietta, Cincinnati, Yellow Springs, and Columbus (all in the Ohio River basin).

C. Diogenes. Kelley's Island, Lake Erie.

C. propinquus, var. *Sanbornii*, at Oberlin, in the northern part of the State.

C. rusticus. Kelley's Island, Lake Erie; Miami River, Dayton; Yellow Springs; Ohio River, Cincinnati.

24. Indiana. — Ten species: *C. Blandingii*, var. *acuta*, *C. pellucidus*, *Bartonii*, *Diogenes*, *argillicola*, *immunis*, *Sloanii*, *propinquus*, *virilis*, and *rusticus*. Perhaps also *C. Putnami* in the southern part of the State.

C. Blandingii, var. *acuta*, has been received from Wheatland, Knox Co., in the southeastern part of the State.

C. pellucidus inhabits Wyandotte Cave, Crawford Co., and caves in Harrison Co. Both of these counties are on the southern border of the State.

C. Bartonii has been collected at New Albany, on the Ohio River, and at Indianapolis.

C. Diogenes is recorded from Long Lake, Kendallville, Noble Co.; Mechanicsburg, Henry Co.; ~~and Knox Co.~~

C. argillicola is found at New Albany.

C. immunis comes from White River; Fall Creek, Indianapolis; and Long Lake, Kendallville.

C. Sloanii. New Albany.

C. propinquus seems to be a common and widely distributed species. Known localities: Elkhart River, Rome City, Noble Co.; Delphi; Indianapolis; White River; Switz City; Michigan City; Turman Creek, Sullivan Co.; Clear Creek, Bloomington.

C. virilis. Michigan City; Long Lake, Kendallville; Elkhart River, Rome City. All of these places are in the northern part of the State.

C. rusticus. Ohio River, Madison; White River; Indianapolis.

25. ILLINOIS. — Eight species: *C. Blandingii*, var. *acuta*, *C. gracilis*, *C. Bartonii*, var. *robusta*, *C. Diogenes*, *C. immunis*, *C. propinquus*, *C. virilis*, and *C. rusticus*.

C. Blandingii, var. *acuta*. This is a very common species in Illinois. It is recorded from Athens, Decatur, Pekin, Normal, Oquawka, Peoria, Lawn Ridge, and Evanston.

C. gracilis. Normal, Lawn Ridge, Athens. "Very common along watercourses in early spring." Forbes.

C. Bartonii, var. *robusta*. One locality in the State, viz. Decatur.

C. Diogenes. Lawn Ridge, Evanston, Belleville, Decatur, Chicago, and Abingdon. Very common.

C. immunis. Aux Plains [?], Belleville, Lawn Ridge, Normal, and Oquawka. "The commonest species of Central Illinois. It is especially frequent in the muddy ponds of the prairies." Forbes.

C. propinquus. Freeport; Ogle Co.; Geneva; Pekin; Normal; Decatur; Aux Plains River.

C. virilis. Quincy; Lawn Ridge; Decatur; Normal; Pekin; Cairo; Geneva; Stillman's Creek, Marion.

C. rusticus. Quincy (*C. placidus* Hagen); Normal.

C. troglodytes has been cited by Hagen as an Illinois species on the authority of a single specimen in the Museum of Comparative Zoölogy (No. 197) marked "Lawn Ridge, Ill., O. Ordway." I am inclined to think the label erroneous.

26. KENTUCKY. — Nine species: *C. pellucidus*, *C. Bartonii*, *C. Diogenes*? *C. dubius*, *C. cornutus*, *C. Sloanii*, *C. propinquus*, var. *Sanbornii*, *C. rusticus*, and *C. Putnami*.

C. pellucidus. Mammoth Cave and other caves in Edmonson Co.

C. Bartonii. Cumberland Gap, Josh Bell Co.; Smoky Creek, Carter Co.; Kentucky River, Little Hickman, Jessamine Co.; Bear Creek, Grayson's Springs, Grayson Co.; Mammoth Cave, Edmonson Co.

C. dubius. Cumberland Gap.

C. cornutus. Green River near Mammoth Cave.

C. Sloanii. Neighborhood of Louisville?

C. propinquus, var. *Sanbornii.* Smoky Creek, Carter Co.

C. rusticus. Kentucky River, Little Hickman; Perryville, Boyle Co.; Salt River; Cumberland Gap.

C. Putnami. Grayson Springs; Green River, near Mammoth Cave; Cumberland Gap.

27. TENNESSEE. — Twelve species: *C. Blandingii*, var. *acuta*, *C. Bartonii*, *C. latimanus*, *C. dubius*, *C. extraneus*, *C. hamulatus*, *C. immunis*, var. *spinirostris*, *C. Palmeri*, *C. rusticus*, *C. spinosus*, *C. Putnami*, and *C. forceps*? Probably also *C. virilis* and *C. Diogenes*. (See pages 72, 98.)

C. Blandingii, var. *acuta.* Memphis.

C. Bartonii. Cumberland Gap; Doe River, Carter Co.; Lineville Cave, near Blountsville, Sullivan Co.; Knoxville.

C. latimanus. Ashland City, Cheatham Co. (Cumberland River). (See page 69.)

C. dubius. Cumberland Gap.

C. extraneus. Tennessee River, near the border of Georgia.

C. hamulatus. Nickajack Cave, in the southern part of the State.

C. immunis, var. *spinirostris.* Obion Co., in the northwestern corner of the State.

C. Palmeri. Obion Co.

C. rusticus. Cumberland Gap; Lebanon.

C. spinosus. Tennessee River, near the border of Georgia.

C. Putnami. Cumberland Gap; Knoxville?

C. forceps? Knoxville. (See page 119.)

28. MICHIGAN. — Four species: *C. Diogenes*, *argillicola*, *immunis*, and *propinquus.* Also *C. Bartonii* and *C. rusticus* in Lake Superior.

C. Diogenes and *C. immunis* have been found at Detroit.

C. argillicola, at Detroit and East Saginaw.

C. propinquus, in St. Clair River and Detroit River; at Northville; Ann Arbor; Ecorse; and Otsego (Kalamazoo River).

29. WISCONSIN. — Seven species: *C. Blandingii*, var. *acuta*, *C. gracilis*, *Diogenes*, *immunis*, *propinquus*, *virilis*, and *rusticus.*

C. Blandingii, var. *acuta*, is recorded from Racine, on Lake Michigan, and from Sauk City, on the Wisconsin River.

C. gracilis. Racine.

C. Diogenes. Tributaries of Pecatonica River, Green Co.; Appleton; Racine.

C. immunis. Milwaukee.

C. propinquus. Tributaries of Pecatonica River, Green Co.; Madison.

C. virilis. This appears to be common. It has been received from Appleton; Baraboo River, Ironton; Sauk City; Wisconsin River; Sugar River; Rock River; Jefferson; and Milwaukee.

C. rusticus. Racine; Beloit; Ironton; Fox River.

30. MINNESOTA. — Two species: *C. immunis* and *C. virilis*, the former from Richfield, Hennepin Co., the latter from Lake Superior, Mississippi River, and lakes and streams in Hennepin Co.

31. IOWA. — Seven species: *C. Blandingii*, var. *acuta*, *C. gracilis*, *Diogenes*, *immunis*, *propinquus*, *virilis*, and *rusticus.*

C. Blandingii, var. *acuta.* West Liberty, Dubuque.

C. gracilis and *C. Diogenes.* Davenport.

C. propinquus. Davenport; Ottumwa.

C. immunis. West Liberty.

C. virilis. Davenport; Burlington; Fort Dodge; Spring Vale; Des Moines River; Bedford.

C. rusticus. Lizard Creek, Fort Dodge.

The State has been little explored. All of the above-named localities are on the eastern border of the State, except Fort Dodge and Spring Vale, which are in the central part.

32. Missouri. — Seven species: *C. Blandingii*, var. *acuta*, *C. Diogenes*, *medius*, *immunis*, *Harrisonii*, *virilis*, and *rusticus*. Possibly *C. Bartonii* in the Osage River. (See page 61.)

C. Blandingii, var. *acuta*, occurs at St. Louis.

C. Diogenes. Carroll Co. and St. Louis.

C. medius. Irondale, Washington Co.

C. immunis. St. Louis.

C. Harrisonii. Irondale, Washington Co.

C. virilis. St. Louis; Osage River; Irondale.

C. rusticus. Osage River.

33. Arkansas. — Four species: *C. Diogenes*, *virilis*, *rusticus*, and one undetermined species belonging to the *C. Blandingii* group.

C. Diogenes. Locality unknown.

C. virilis. White River, Eureka Springs.

C. rusticus. White River, Eureka Springs.

Sp. indet. Salina River, Arkadelphia.

34. Indian Territory. — None.

35. Kansas. — Four species: *C. simulans*, *Diogenes*, *immunis*, and *virilis*.

C. simulans. Fort Hays.

C. Diogenes. Leavenworth.

C. immunis. Leavenworth; Ellis.

C. virilis. Leavenworth; Manhattan; Republican River northwest of Fort Riley; Ellis.

36. Nebraska. — One species, *C. virilis*, from Omaha, on the eastern border of the State.

37. Dakota Territory. — Three species: *Cambarus Nebrascensis*, *C. virilis*, and *Astacus Gambelii*.

C. Nebrascensis from Fort Pierre, at the confluence of the Bad and Missouri Rivers (Girard).

C. virilis from the Red River of the North, near Pembina, and from the Souris or Mouse River.

A. Gambelii from the mouth of the Yellowstone River, on the boundary between the Territories of Dakota and Montana (the easternmost locality for the genus Astacus).

38. Montana Territory. — One species, *Astacus Gambelii*, from the mouth of the Yellowstone River.

39. Wyoming Territory. — Three species: *C. Diogenes*, *immunis*, and *virilis*. Perhaps also *Astacus Gambelii*. (See page 137.)

C. Diogenes has been found at Cheyenne.

C. immunis and *C. virilis* at Laramie City.

40. Colorado. — One species, *C. Diogenes*, from Clear Lake. I do not know in what part of the State this is.

41. New Mexico Territory. — None.

42. Arizona Territory. — None.

43. Utah Territory. — One species, *Astacus Gambelii*, from Ogden River, Ogden.

44. Nevada. — None.

45. Idaho Territory. — One species, *A. Gambelii*, from Fort Hall on the Snake River, and from the west side of Teton Basin.

46. Washington Territory. — Four species: *A. Klamathensis*, *A. leniusculus*, *A. Trowbridgii*, and *A. nigrescens*.

A. Klamathensis from the section east of the Cascade Range, at Fort Walla Walla, Wenas Valley, and Spokane Falls (upper part of the Columbia River and tributaries).

A. leniusculus from the lower part of the Columbia River and Puget Sound.

A Trowbridgii. Lower part of Columbia River, near Astoria; streams running into Shoalwater Bay.

A. nigrescens. Fort Steilacoom on Puget Sound. (See page 135.)

47. Oregon. — Three species: *A. Klamathensis*, *A. leniusculus*, and *A. Trowbridgii*..

A. Klamathensis. Klamath Lake; Sikan Creek; and Des Chutes River.

A. leniusculus. Lower part of the Columbia River.

A. Trowbridgii. Columbia River near Astoria.

48. California.* — Two species: *A. Klamathensis* and *A. nigrescens.* Perhaps also *A. Gambelii.* (See page 137.)

A. Klamathensis in Klamath Lake on the northern border of the State, and in Eel River.

A. nigrescens from the neighborhood of San Francisco. central

49. Alaska Territory. — One species, *A. nigrescens*, from Oonalaska Island.

50. Dominion of Canada. — Four species: *Cambarus Bartonii* (including var. *robusta*), *C. argillicola*, *C. propinquus*, and *Astacus Klamathensis.* *C. Diogenes*, which occurs at Detroit, Mich., will doubtless be found on the Canadian side of the river.

C. Bartonii. St. John, Prov. New Brunswick; Montreal, Prov. Quebec?

C. Bartonii, var. *robusta.* Toronto and Weston, Prov. Ontario.

C. argillicola. Toronto, Prov. Ontario.

C. propinquus. Montreal, Prov. Quebec; Toronto, Prov. Ontario.

A. Klamathensis. Streams east of Cascade Mountains, Prov. British Columbia.

51. Mexico. — Four † species: *C. Wiegmanni*, *Mexicanus*, *immunis*, and *Montezumæ.* But little is known concerning the distribution of these species in Mexico. The only specimen of *C. Mexicanus* which I have seen came from Mirador. The locality given by Saussure for *C. Aztecus* (= *C. Mexicanus*?) is "Tomatlan, dans les Terres-Chaudes." Von Martens records the same species from Puebla. *C. immunis* has been found at Orizaba, *C. Montezumæ* in the neighborhood of the city of Mexico, at Puebla, Parras in the State of Cohahuila, and at Mazatlan on the Pacific coast. A mutilated specimen, probably *C. Wiegmanni*, in the U. S. National Museum, comes from the Isthmus of Tehuantepec.

* In the U. S. National Museum there is a small specimen of *Cambarus obscurus* labelled "California" (No. 2531). The locality is probably erroneous.

† *Five* species, if *C. Aztecus* Saussure be distinct from *C. Mexicanus* Erichson. (See page 51.) An undescribed species belonging to the Parastacinæ was collected by John Xantus at Colima, on the west coast. This is the only Parastacine yet discovered north of the equator.

52. Guatemala. — A species of Cambarus was obtained by Mr. Salvin near Coban, in the Province of Alta Vera Paz, at an elevation of about 4,300 feet above the sea. (See Huxley, Proc. Zoölog. Soc. London, 1878, p. 763; The Crayfish, p. 312, fig. 78; also page 7 of this work.) This is the most southern locality from which the genus Cambarus has been obtained.

53. Cuba. — One species, *C. Cubensis*. The examples in the Museum of Comparative Zoölogy were obtained near Havana. According to Von Martens there are indications of a second species of Cambarus native to Cuba. (See page 53.)

Distribution of the North American Species of Cambarus and Astacus according to the River Systems.

Viewing the distribution of the various species according to the river systems, it appears that the St. John, Penobscot, and Kennebec Rivers are inhabited by only a single species, *C. Bartonii*. In the remaining large rivers of New England, the Androscoggin, the Saco, the Merrimac, and the Connecticut, crayfishes are unknown. *C. Bartonii* has been found in springs at Grafton, Mass., in the Blackstone River basin.

In the Hudson River basin *C. Bartonii* is widely distributed. Near the mouth of this river, in Essex Co., New Jersey, *C. Blandingii* occurs. This is probably its northern limit in the east.

From the Delaware and its tributaries come *C. Blandingii, Bartonii, Diogenes,* and *affinis*.

In the area drained by the rivers that empty into Chesapeake Bay, the chief of which are the Susquehanna, Potomac, Rappahannock, and James, are found *C. Blandingii, C. Bartonii, C. Bartonii,* var. *robusta, C. Diogenes, Uhleri,* and *affinis*. *C. Uhleri* is known only in the low region on the Chesapeake and Atlantic coasts of Maryland, often in brackish and salt water.

The rivers of North Carolina (Roanoke, Tar, Neuse, Cape Fear, and tributary streams) are inhabited by *C. Blandingii, Bartonii,* and *Diogenes*.

The Santee River and the minor streams of South Carolina yield *C. Blandingii, C. Blandingii,* var. *acuta, C. troglodytes, Carolinus, acuminatus, latimanus, spinosus,* and *Bartonii,* the last species in the head-waters of the Santee among the mountains of Western North Carolina.

The rivers which flow into the Atlantic Ocean in the State of Georgia (Savannah, Altamaha, etc.) furnish *C. Blandingii, pubescens, troglodytes, Lecontei, spiculifer, penicillatus,* and *latimanus*. In the lower part of the State are also found *C. advena, angustatus,* and *maniculatus*.

In the St. John's River, Florida, have been found *C. fallax, Clarkii,* and *Alleni*. *C. fallax* and *C. Alleni* have not been found outside of the State of Florida.

In the upper portion of the Chattahoochee River live *C. spiculifer* and *C. latimanus*.

In the upper part of the course of the Alabama River (Etowah, Oostenaula, and Coosa Rivers), *C. extraneus, Jordani,* and *spinosus* have been secured; in the upper part of the Tombigbee, *C. Blandingii,* var. *acuta, C. latimanus, Hayi,* and *Mississippiensis*. At Mobile, where the Alabama and Tombigbee, after uniting, empty into Mobile Bay, *C. Blandingii,* var. *acuta, C. Clarkii, Lecontei,* and *versutus* occur.

Mississippi River System. — From the portion of the Mississippi Valley south of the

Ohio and its affluents are recorded *C. Blandingii*, var. *acuta*, *C. Clarkii* (near the mouth of the river, at New Orleans, etc.), *C. Diogenes*, *C. immunis*, var. *spinirostris*, and *C. Palmeri* (Obion Co., Tennessee), *C. virilis* and *C. rusticus* (from White River, Arkansas), and *C. Shufeldtii* (New Orleans).

In the region drained by the Tennessee River are found, (*a.*) in the upper part of its course, *C. Bartonii*, *dubius* (Cumberland Gap), *rusticus* (Cumberland Gap), *Putnami*, *extraneus*, *hamulatus*, and *spinosus* (the last three from near the border of the State of Georgia). (*b.*) In the southern bend of the river, within the State of Alabama, *C. Blandingii*, var. *acuta* (Bridgeport and Decatur), *C. latimanus* (Bridgeport), *immunis* (Huntsville), *Girardianus*, *Alabamensis*, *compressus*, *spinosus*, and *forceps* (the last five species from Lauderdale Co. in the northwestern corner of Alabama).

In the Ohio River and its tributaries (excepting the Tennessee) are found *C. Blandingii*, var. *acuta*, *C. pellucidus*, *Bartonii*, *Diogenes*, *argillicola*, *dubius* (Preston Co., W. Va., Cumberland Gap, Ky.), *cornutus*, *immunis*, *virilis* (Cairo, Ill.), *rusticus*, *Putnami*, *Sloanii*, *propinquus*, and *C. propinquus*, var. *Sanbornii*.

In the Mississippi Valley to the north of the Ohio are found *C. Blandingii*, var. *acuta*, *C. gracilis*, *C. Diogenes*, *C. Bartonii*, var. *robusta* (Decatur, Ill.), *C. medius* (Irondale, Mo.), *C. Harrisonii* (Irondale, Mo.), *C. immunis*, *virilis*, *rusticus*, and *propinquus*.

From the Missouri and its affluents come *C. simulans* (Fort Hays, Kan.), *C. Nebrascensis* (Fort Pierre, Dakota), *C. Diogenes* (Colorado, Wyoming, Kansas), *C. immunis* (Laramie City, Wyo., Leavenworth, Kan.), *C. virilis* (Laramie City, Wyo., Nebraska, Iowa, Kansas), and *Astacus Gambelii* (at the confluence of the Yellowstone and the Missouri, and perhaps also in the Platte River drainage in Wyoming).

But little is known concerning the distribution of crayfishes in the rivers that flow into the Gulf of Mexico west of the Mississippi. *C. Clarkii*, *simulans*, *virilis*, and *rusticus* have been collected in Texas; *C. Wiegmanni*, *Mexicanus*, *Azteeus* (= *C. Mexicanus* ?), *immunis*, and *Montezumæ*, in Mexico.

The island of Cuba affords a peculiar species, *C. Cubensis*.

In the great basin of the St. Lawrence River are found *C. Blandingii*, var. *acuta*, *C. Bartonii*, *C. Bartonii*, var. *robusta*, *C. Diogenes*, *C. argillicola*, *C. gracilis*, *C. immunis*, *C. virilis*, *C. rusticus*, *C. propinquus*, *C. propinquus*, var. *Sanbornii*, *C. propinquus*, var. *obscura*, and *C. affinis*. Of these, *C. virilis*, *rusticus*, *propinquus*, and *Bartonii* are found in Lake Superior; *C. Blandingii*, var. *acuta*, *C. gracilis*, *Diogenes*, *immunis*, *virilis*, *rusticus*, and *propinquus*, in Lake Michigan and its affluents; *C. argillicola* and *C. propinquus*, in the Lake Huron drainage; *C. Bartonii*, *C. Bartonii*, var. *robusta*, *C. Diogenes*, *C. argillicola*, *C. immunis*, *C. propinquus*, *C. propinquus*, var. *Sanbornii*, and *C. rusticus*, in Lake Erie and tributary streams; in Lake Ontario and its affluents, *C. Bartonii*, *C. Bartonii*, var. *robusta*, *C. argillicola*, *C. propinquus*, *C. propinquus*, var. *obscura* (Rochester, N. Y.), and *C. affinis* (Niagara). In the St. Lawrence and its affluents from the lower end of Lake Ontario down to Montreal are found *C. Bartonii* and *C. propinquus*; in Lake Champlain and tributary streams, *C. Bartonii*.

In the Hudson's Bay water-shed, *C. virilis* occurs in Lake Winnipeg, Saskatchewan River, and the Red River of the North.

The basin of the Great Salt Lake is inhabited by *Astacus Gambelii*.

The upper waters of the Columbia River furnish *Astacus Gambelii* (head of Snake River, Idaho) and *A. Klamathensis*. These are replaced by *A. leniusculus* and *A. Trowbridgii* in the lower part of the Columbia. *A. Klamathensis* is also found in the upper part of the rivers of British Columbia, and as far south as Klamath Lake on the north-

ern bounds of California. From the neighborhood of San Francisco, California, comes *A. nigrescens*, a species which apparently extends far north along the coast, as there are specimens in the U. S. National Museum said to have been taken at Fort Steilacoom, Washington Territory, and Oonalaska Island, Alaska Territory (lat. 53° 52′ N.).

On the west coast of Mexico, at Mazatlan, a Cambarus occurs, *C. Montezumæ;* also a Parastacine at Colima.

General Conclusions derived from the Facts known concerning the Geographical Distribution of Crayfishes.

I. The crayfishes of the Southern hemisphere (Australia, Tasmania, New Zealand, Feejee Islands, Madagascar, and South America) possess certain characters in common (given on page 2) which separate them as a subfamily, Parastacinæ, from the crayfishes of the Northern hemisphere (Europe, Asia, and North America), which form a second subfamily, Potamobiinæ (page 2). This was first pointed out by Huxley,* who suggests, in explanation of this fact in the distribution of the crayfishes, that their marine ancestors were already differentiated into a Parastacine type in the Southern hemisphere and a Potamobiine type in the Northern hemisphere, when they took possession of the fresh waters. The distribution of the different genera of Parastacinæ in the Southern hemisphere will be considered in the second part of this memoir.

II. The crayfishes belonging to the subfamily Potamobiinæ occupy four geographical areas, viz.: —

(1.) The eastern and central part of the North American continent. This area embraces that portion of North America which lies east of the Rocky Mountains, drained by the rivers that flow into the Atlantic Ocean, Hudson's Bay, and the Gulf of Mexico, from Lake Winnipeg on the north to Guatemala on the south. It includes the island of Cuba.

(2.) The western slope of the North American continent, or the area drained by the rivers that flow into the Pacific Ocean. In this area is included the basin of the Great Salt Lake, which probably drained into the Pacific at a former period.

(3.) A tract on the eastern side of Asia, including the Amoor River basin and Japan.

(4.) An area including the greater part of Europe, and extending into Western Asia so as to embrace the Aralo-Caspian basin.

Thus we have an eastern North American and a western North American area, an eastern Eurasiatic † and a western Eurasiatic area. The two areas in North America are in close juxtaposition at the Rocky Mountain divide, whereas the eastern and western Eurasiatic crayfishes are sundered by a broad tract in Central Asia whose waters are wholly destitute of these animals, as far as known.

III. (1.) The western Eurasiatic and the western North American crayfishes belong to the genus Astacus (page 125). They are closely related, the European species differing from the western North American species barely more than the latter do from each other. (2.) The eastern North American crayfishes (Cambarus, page 3) are generically distinct from the western North American and European species. (3.) The eastern Eurasiatic crayfishes form a natural group (Cambaroides, page 126), in which the characters of Astacus and Cambarus are combined.

* Proc. Zoölog. Soc. London, 1878.

† Eurasia is the single continent artificially divided into Europe and Asia.

In other words, the Astaci of Western North America find their closest kin, not in their next neighbors, the crayfishes on the eastern side of the Rocky Mountains, nor in those of Eastern Asia, but in the Astaci of Europe; the Cambari of Eastern North America are most nearly related, not to the crayfishes on the other side of the Rocky Mountains, nor to those on the opposite shore of the Atlantic, but to those of the remotest district, Eastern Asia. The two areas inhabited by Astacoid forms alternate with two areas of Cambaroid forms.

"If the facts had been the other way," says Huxley,* "and the West American and Amoor-Japanese crayfish had changed places, the case would have been intelligible enough. The primitive Potamobine stock might then have been supposed to have differentiated itself into a western Astacoid and an eastern Cambaroid form; the latter would have ascended the American, and the former the Asiatic rivers. As the matter stands, I do not see that any plausible explanation can be offered without recourse to suppositions respecting a former more direct communication between the mouth of the Amoor and that of the North American rivers, in favor of which no definite evidence can be offered at present."

In order to explain this singular mode of distribution of the Potamobiinæ, let it be supposed that the marine progenitors of the existing crayfishes were differentiated, not only into a northern type with the Potamobiine characters and a southern type with the Parastacine characters, but that the Potamobiine type was already differentiated into an Astacoid form and a Cambaroid form (with some of the essential characters of the modern Cambarus), both of which became widely distributed around the globe in the ocean which lay to the north of the ancient continents. After their adaptation to life in fresh water, both forms would be driven southward by the climatic changes which have occurred within comparatively recent geological periods, into all parts of each continent.† The same causes, whether similar climatic conditions or other, which have operated in the preservation of so many allied forms of plants and animals on the corresponding sides of the Eastern and Western continents, would promote the survival of the descendants of the one type of crayfish in Eastern North America and Eastern Asia, of the other in Western North America and Europe. Unfortunately, we have no palæontological evidence touching the former distribution of Astacus and Cambarus, the few fossils known being too imperfect for the purpose; but the assumption of the former coexistence of Astacus and Cambarus in the same area of distribution receives positive support from the fact that a blind Cambarus still survives in the subterranean seclusion of the caves of Carniola. (See page 42.) It will, moreover, be borne in mind, that in other cases of animals and plants that exemplify the same peculiarities of distribution with the crayfishes, direct palæontological evidence is not wanting to prove the former general distribution of forms now restricted to widely separated localities. To instance a remarkable case among the marine Crustacea, the peculiar genus Limulus is represented on the eastern coast of North America by *L. Polyphemus*. No Limuli exist on the Pacific shores of America nor on the coasts of Europe, but closely related species inhabit the eastern side of Asia (Japan, Cochin China, the Moluccas, etc.). Now, in the lithographic slates of Solenhofen abundant fossil Limuli clearly testify to their former existence in the seas of Europe.

The reader will observe that in this suggestion of a possible explanation of the peculiar relations existing between the crayfishes of Western North America and of Europe on

* The Crayfish, p. 334.

† That the crayfishes had become fresh-water animals in Tertiary times is shown by the fossils of Idaho and Wyoming.

the one hand, and between those of Eastern North America and of Eastern Asia on the other, I have simply made a new application of the theories advanced by Huxley* to explain the differences between the crayfishes on the two sides of the equator, and by Asa Gray † to account for phenomena in the distribution of plants similar to those presented by the crayfishes of the Northern hemisphere.

The absence of Astacidæ over a large part of Asia is well known. None are found in the great rivers that flow into the Arctic Ocean, nor in those of the central and southern portions of the continent. In connection with the absence of crayfishes from the rivers of Southern Asia, Milne Edwards‡ has suggestively observed that these waters are populous with fluviatile crabs of the family Telphusidæ. Indeed, as a general rule, crayfishes are unknown in regions where fluviatile crabs abound, having succumbed, perhaps, to their more highly organized rivals. Huxley remarks, moreover, that if the western Eurasiatic crayfishes are derived from a primitive Aralo-Caspian stock, as seems probable, the great Asiatic highlands would form an obstacle to their southward extension into India, while the severity of the Siberian winter and the recent submergence of the land beneath the ocean are invoked to account for the absence of these animals from the great Asiatic rivers that empty into the Arctic Ocean.

IV. The only islands in the Northern hemisphere known to be inhabited by crayfishes lie near the mainland, and the crayfishes contained therein are either the same species as those of the adjacent part of the continent, or closely related species. Thus, the species found in England and Ireland and in the islands of Cherso and Veglia are the same as those of the western and southern parts of Continental Europe, viz. *Astacus pallipes*. The Japanese crayfishes (*Cambaroides Japonicus*) are nearly related to those of the Amoor River (*Cambaroides Dauricus* and *C. Schrenckii*), the Cuban species (*Cambarus Cubensis*) to those of Mexico (*C. Mexicanus*). The chances in favor of accidental transportation of animals having the habits of crayfishes across bodies of salt water such as separate the islands in question from the continents are so small, that it seems more probable that their distribution was effected through migrations at a former period, when the present insulated areas were continuous with the neighboring continents. The connection of the British Isles with the continent of Europe in post-glacial times is admitted by geologists. Evidence pointing to the former connection of the islands of the West Indian archipelago with each other and with the mainland has been obtained already from the land fauna and flora of these islands.§

V. Blind crayfishes have been found in the caves of Carniola and the United States. The Carniola blind crayfish is not merely specifically, but even generically, distinct from the other species of Europe, and belongs to the same genus as the crayfishes of the Atlantic slope of North America (Cambarus). As the genus Cambarus in North America was not developed under the influences affecting cavern life, it would seem that the generic identity of the Carniola cave species with the North American forms cannot be due to similarity of surroundings, but rather to genetic connection. In other words, it is probable

* *Op. cit.*

† Mem. Amer. Acad. Arts and Sci., New Series, VI. 377–452, 1857. — Proc. Amer. Assoc. Adv. Sci., 21st Meeting, pp. 1–31, 1873.

‡ Histoire Naturelle des Crustacés, III. 584, 1840.

§ Cf. Bland, Proc. Amer. Philosoph. Soc., XII. 56, 1871; Ann. Lyc. Nat. Hist. N. Y., X. 311, 1874; Ann. N. Y. Acad. Sci., II. 117, 1880. Eggers, Bull. U. S. Nat. Mus., No. 13, 1879. The *extinct* fauna of Cuba includes a giant sloth, Megalonyx (Leidy, Proc. Acad. Nat. Sci. Phila., 1868, p. 178); and in the little island of Anguilla, which is only thirty-five square miles in area, are found the fossil remains of several species of gigantic rodents and a deer (Cope, Proc. Amer. Philosoph. Soc., XI. 183, 1869; Ibid., XI. 608, 1870).

that the genus Cambarus once flourished in the rivers of Europe. (See pages 42, 176.) The cave species of the United States belong to the same genus as those inhabiting the outside waters, but are not closely related to any of them. They may be considered as derived from an ancient outside fauna of that region. (See page 42.)

VI. The genus Cambarus ranges from Lake Winnipeg to Cuba and Guatemala, from New Brunswick to Wyoming Territory (in Mexico to the Pacific Ocean). Like the Unionidæ of the same waters, the Cambari are wonderfully rich in species, the evolution of specific forms having gone on much more rapidly here than in the regions inhabited by their relatives, the Astaci. Within the limits of the United States west of the Rocky Mountains, and in Mexico and Cuba, fifty-two species of Cambarus are known, while the described Astaci (including the subgenus Cambaroides) of Europe, Asia, and the Western United States number but fourteen species, the chances of discovery of new species through further exploration being greatly in favor of the genus Cambarus.

With regard to the distribution of the species of Cambarus, the whole territory occupied by them seems to fall into two provinces; — a southern province, embracing the Atlantic States south of North Carolina, the Gulf States, Mexico, and Cuba; and a northern province, which includes the Atlantic States north of South Carolina, the States of the Mississippi Valley (*in sensu extenso*) north of the Gulf States, and Canada. The southern province is characterized by the prevalence of species belonging to Groups I. and II. (*C. Blandingii* and *C. advena* groups). All of the fifteen species of Group I., excepting *C. pellucidus*, are found within the limits of this province as defined above. *C. pellucidus* comes from the caves of Kentucky and Southern Indiana. Five of the six species belonging to Group II. are found in the southern province; the fifth, *C. gracilis*, is a northern species (Wisconsin, Iowa, Illinois). *C. simulans* has been found in Texas and to the northward in Kansas. The only two species belonging to Group V. (*C. Montezumæ* and *C. Shufeldtii*) are confined to the southern province, in Mexico and Louisiana. One species belonging to Group I., *C. Blandingii*, extends northward beyond the limits of the southern province as far as New York along the Atlantic coast, and up to Wisconsin in the Mississippi Valley. In both the East and the West, the northern form distinctly differs from the southern. (See page 22.)

Besides the species of Cambari belonging to Groups I., II., and III., there are found within the limits of the southern province six species* belonging to Group III. (*C. Bartonii* group), and nine species† of Group IV. (*C. affinis* group). Only eight of them, however, are restricted to the southern province; and of these eight, three (*C. Girardianus, Alabamensis*, and *compressus*) are known only from the extreme northwestern corner of Alabama, in the Tennessee River basin, while three (*C. acuminatus, latimanus*, and *Jordani*) chiefly inhabit the upper portions of the river-courses in the mountainous regions of the province. *C. extraneus* and *C. spinosus* are border species with respect to the two provinces, being found in the streams on each side of the Alleghany divide, in South Carolina, Georgia, and Tennessee. *C. Diogenes, immunis, virilis*, and *rusticus* have their populous centres of distribution in the north, although they have extended far southward on certain lines.

In the northern province the species of the third and fourth groups (allies of *C. Bartonii* and *C. affinis*) are the dominant forms, wellnigh to the exclusion of those belonging to the first and second groups. Nine species belonging to Group III. and eleven to

* *C. acuminatus*, *C. latimanus*, *C. Diogenes*, *C. extraneus*, *C. Girardianus*, and *C. Jordani*.

† *C. immunis*, *C. Mississippiensis*, *C. Alabamensis*, *C. compressus*, *C. lancifer*, *C. virilis*, *C. rusticus*, *C. spinosus*, and *C. forceps*.

Group IV. are found here, while Groups I. and II. are represented by only two species each, *C. Blandingii* and *pellucidus*, and *C. simulans* and *gracilis*. The southern province contains thirty-six species, twenty-eight of which are not found beyond its limits. From the northern province twenty-four species are known, sixteen of them peculiar to it.

VII. In the territory occupied by the genus Cambarus the waters of the South and West are richer in species than the waters of the Northeast. This will appear evident on inspection of the table of distribution according to States, on page 165, or according to river systems, on page 173. The well-explored New England States afford but one species; Pennsylvania, four or five;—while the less narrowly searched States to the south and west yield much larger numbers; as Alabama, eleven; Georgia, thirteen; Tennessee, twelve; Indiana, ten.

VIII. The crayfishes of the upper part of a river basin are often different from those found in the lower part of its course,* even when the river does not traverse a great distance in latitude. The distinction between the species of the upper waters and those of the lower waters is most marked in rivers that have a heavy fall from their source to their mouth. In the upper waters of the Santee basin, for instance, *C. Bartonii, latimanus, acuminatus*, and *spinosus* are found; in the lower portion of the same basin live *C. Blandingii*, var. *acuta*, and *C. troglodytes*. So with Astacus: the lower part of the Columbia River, near its mouth, is frequented by *A. leniusculus* and *A. Trowbridgii;* while above the Cascades *A. Klamathensis* is found, and yet higher, in the head-waters of the Snake River in Idaho, *A. Gambelii*.

IX. Distribution is often controlled by the character of the stream (temperature, rapidity, purity, etc.) rather than by continuity of water communication. Thus, a species of restricted range may be found in the upper waters of streams that rise in the same mountain range, but flow in opposite directions and discharge at points far distant, and yet be unknown in the lower portions of the same streams. For example, *C. extraneus* and *C. spinosus* are found in the upper waters of the Santee, Alabama, and Tennessee River systems. This fact is more easily explained in the case of crayfishes, many of which possess a singular faculty for living a long time away from the water, than in the case of fresh-water fishes, where the same phenomenon of distribution has been pointed out by Cope and by Jordan.†

* This was observed by Agassiz in the case of fishes and mollusks. See his "Lake Superior," p. 247, Boston, 1850.

† See Cope, Journ. Acad. Nat. Sci. Phila., New Series, VI. 207 *et seqq.*, and Jordan, Bull. U. S. Nat. Mus., No. 12.

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EXPLANATION OF THE PLATES.

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PLATE III.

Fig. 1. Cambarus Harrisonii Fax. Male, form I. Irondale, Mo. . . . . × 2
" 2. Cambarus Mississippiensis Fax. Male, form I. Eastern Mississippi. . . . . × 1½
" 3. Cambarus Jordani Fax. Male, form II. Rome, Ga. . . . . × 2
" 4. Cambarus medius Fax. Male, form I. Irondale, Mo. . . . . × 2
" 5. Cambarus acuminatus Fax. Female. Saluda River, S. C. . . . . × 2
" 6. Cambarus Palmeri Fax. Male, form II. Obion Co., Tenn. . . . . × 2

PLATE IV.

Fig. 1. Cambarus Girardianus Fax. Male, form II. Lauderdale Co., Ala. . . . . × 1½
" 2. Cambarus argillicola Fax. Male, form I. Detroit, Mich. . . . . × 2
" 3. Cambarus dubius Fax. Male, form I. Preston Co., W. Va. . . . . × 1½
" 4. Cambarus Alabamensis Fax. Male, form I. Lauderdale Co., Ala. . . . . × 2
" 5. Cambarus Sloanii Bundy. Male, form I. New Albany, Ind. . . . . × 1
" 6. Cambarus hamulatus Fax. Male, form II. Nickajack Cave, Tenn. . . . . × 2

* The rostrum is badly drawn. Compare the description on page 29.
† The acumen of the rostrum is broken off in the specimen here figured.

PLATE V.

Fig. 1. Cambarus cornutus Fax. Male, form I. Green River, Ky. . . . . × 1
" 2. The same. Side view of head.
" 3. Cambarus propinquus, var. Sanbornii Fax. Male, form I. Carter Co., Ky. . . . × 2
" 4. Cambarus forceps Fax. Male, form I. Lauderdale Co., Ala. . . . . × 3
" 5. Cambarus Putnami Fax. Male, form I. Grayson Springs, Ky. . . . . × 2
" 6. Cambarus compressus Fax. Male, form I. Lauderdale Co., Ala. . . . . × 4

PLATE VI.

Fig. 1. Astacus Klamathensis Stimps. Male. Fort Walla Walla, Washington Territory. . × 1
" 2. The same. Male. Sikan Creek, Oregon. . . . . × 1
" 3. Astacus (Cambaroides) Schrenckii Fax. Female. . . . . × 3
" 4. Astacus leniusculus Dana. Male. . . . . × 1

PLATE VII.

Fig. 1. Cambarus Shufeldtii Fax. Female. New Orleans, La. . . . . × 4

Figs. 2–3ª′. *First abdominal appendages of male.*

" 2. Cambarus Blandingii Erichs. Trenton, N. J. Form I., outer side. . . . . × 6
" 2′. The same. Form I., inner side. . . . . × 6
" 2″. The same. Form I., front. . . . . × 6
" 2ª. The same. Form II., front. . . . . × 6
" 2ª′. The same. Form II., inner side. . . . . × 6
" 3. Cambarus Hayi Fax. Form I., outer side. . . . . × 6
" 3′. The same. Form I., inner side. . . . . × 6
" 3ª. The same. Form II., outer side. . . . . × 6
" 3ª′. The same. Form II., inner side. . . . . × 6

PLATE VIII.

First abdominal appendages of male.

Fig. 1ª. Cambarus pubescens Fax. Form II. . . . . × 8
" 1ª′. The same. Form II. . . . . × 8
" 2. Cambarus Alleni Fax. Form I. . . . . × 6
" 2′. The same. Form I. . . . . × 6
" 3. Cambarus simulans Fax. Form I. . . . . × 6
" 3′. The same. Form I. . . . . × 6
" 3ª. The same. Form II. . . . . × 8
" 3ª′. The same. Form II. . . . . × 8
" 4. Cambarus gracilis Bundy. Type. Form I. . . . . × 6
" 4′. The same. Form I. . . . . × 6
" 4″. The same. Form I. . . . . × 6
" 5. Cambarus Cubensis Erichs. Form I. . . . . × 12
" 5′. The same. Form I. . . . . × 12
" 5ª. The same. Form II. . . . . × 12
" 5ª′. The same. Form II. . . . . × 12
" 6ª. Cambarus acuminatus Fax. Form II. . . . . × 12
" 6ª′. The same. Form II. . . . . × 12
" 7. Cambarus dubius Fax. Form I. . . . . × 6
" 7′. The same. Form I. . . . . × 6
" 8. Cambarus Uhleri Fax. Form I. . . . . × 8
" 8′. The same. Form I. . . . . × 8
" 8ª. The same. Form II. . . . . × 12
" 8ª′. The same. Form II. . . . . × 12

PLATE IX.

First abdominal appendages of male.

Fig. 1ª. Cambarus hamulatus Fax. Form II. . . . . × 12
" 1ª′. The same. Form II. . . . . × 12
" 2ª. Cambarus Girardianus Fax. Form II. . . . . × 10
" 2ª′. The same. Form II. . . . . × 10
" 3. Cambarus cornutus Fax. Form I. . . . . × 6
" 3′. The same. Form I. . . . . × 6
" 4. Cambarus medius Fax.* Form I. . . . . × 6
" 4′. The same. Form I. . . . . × 6
" 5. Cambarus forceps Fax. Form I. . . . . × 8
" 5′. The same. Form I. . . . . × 8
" 5ª. The same. Form II. . . . . × 8
" 5ª′. The same. Form II. . . . . × 8
" 6. Cambarus Putnami Fax. Form I. . . . . × 4¼
" 6′. The same. Form I. . . . . × 4¼
" 6ª. The same. Form II. . . . . × 8
" 6ª′. The same. Form II. . . . . × 8
" 7. Cambarus spinosus Bundy? Lauderdale Co., Ala. Form I. . . . . × 6
" 7′. The same. Form I. . . . . × 6
" 7ª. Cambarus spinosus Bundy. Etowah River, Ga. Form II. . . . . × 4
" 7ª′. The same. Form II. . . . . × 4
" 8. Cambarus rusticus Gir. Yellow Springs, Ohio. Form I. . . . . × 6
" 8′. The same. Form I. . . . . × 6
" 8ª. The same. Form II. . . . . × 6
" 8ª′. The same. Form II. . . . . × 6
" 9. Cambarus Harrisonii Fax. Form I. . . . . × 6
" 9′. The same. Form I. . . . . × 6
" 10. Cambarus propinquus, var. Sanbornii Fax. Form I. . . . . × 5
" 10′. The same. Form I. . . . . × 5
" 10ª. The same. Form II. . . . . × 6
" 10ª′. The same. Form II. . . . . × 6

PLATE X.

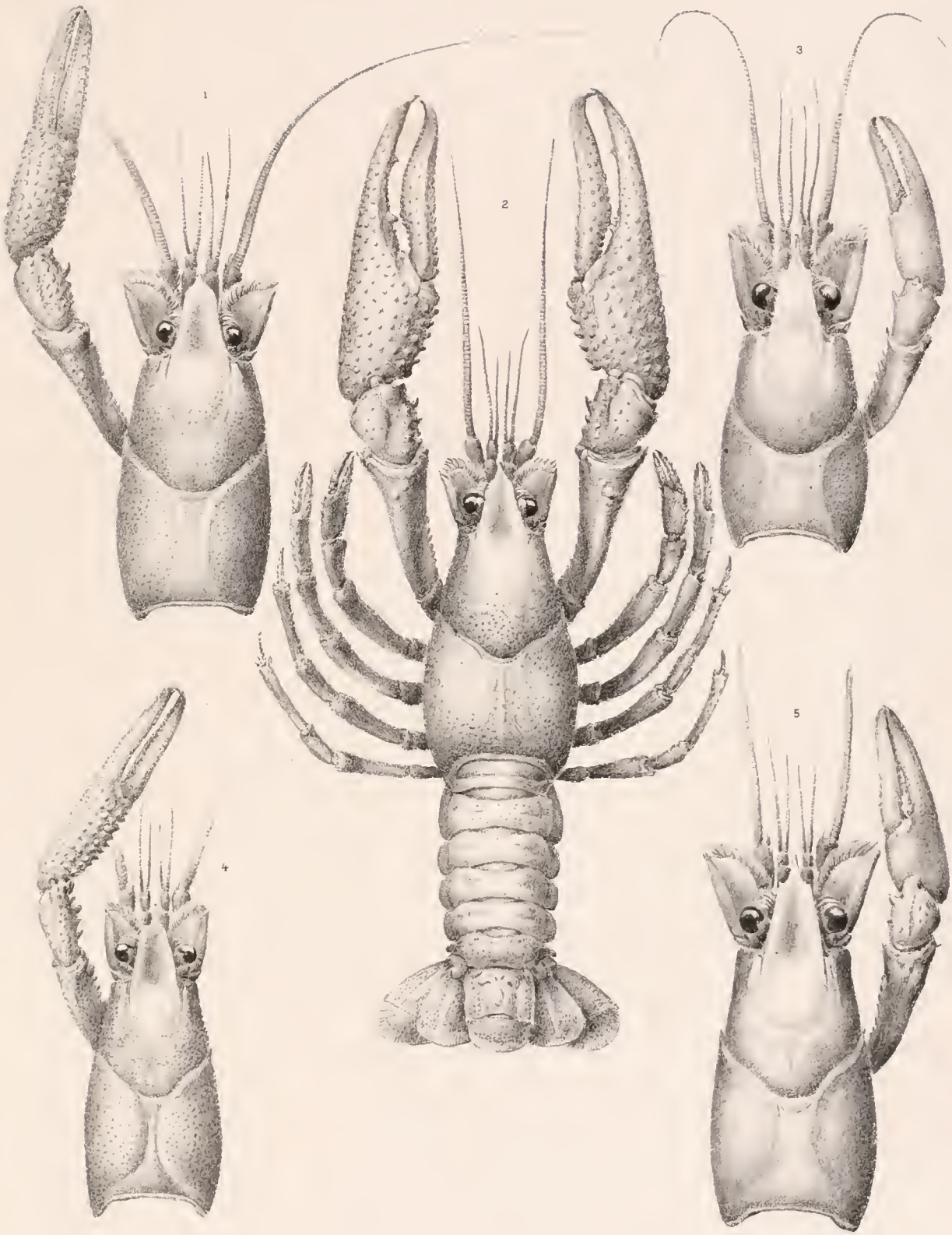
First abdominal appendages of male.

Fig 1. Cambarus Sloanii Bundy. Form I. . . . . × 6
" 1′. The same. Form I. . . . . × 6
" 1ª. The same. Form II. . . . . × 8
" 1ª′. The same. Form II. . . . . × 8
" 2. Cambarus compressus Fax. Form I. . . . . × 8
" 2′. The same. Form I. . . . . × 8
" 2ª. The same. Form II. . . . . × 12
" 2ª′. The same. Form II. . . . . × 12
" 3. Cambarus Alabamensis Fax. Form I. . . . . × 6
" 3′. The same. Form I. . . . . × 6
" 3ª. The same. Form II. . . . . × 6
" 3ª′. The same. Form II. . . . . × 6
" 4. Cambarus Mississippiensis Fax. Form I. . . . . × 6
" 4′. The same. Form I. . . . . × 6
" 4ª. The same. Form II. . . . . × 6
" 4ª′. The same. Form II. . . . . × 6

* The outer ramus was warped by drying when the specimen was in the artist's hands.

Fig. 5ª. Cambarus Palmeri Fax. Form II. . . . . × 6
" 5ª′. The same. Form II. . . . . × 6
" 6ª. Cambarus immunis Hag. Form II. . . . . × 6
" 6ª′. The same. Form II. . . . . × 6
" 7. Cambarus Montezumæ Saus. Form I. . . . . × 20
" 7′. The same. Form I. . . . . × 20
" 7ª. The same. Form II. . . . . × 16
" 7ª′. The same. Form II. . . . . × 16
" 8. Cambarus Shufeldtii Fax. Form I. . . . . × 25
" 8′. The same. Form I. . . . . × 25
" 8ª. The same. Form II.* . . . . . × 30
" 8ª′. The same. Form II. . . . . × 30
" 9. Astacus (Cambaroides) Dauricus Fax. . . . . × 6
" 9′. The same. . . . . × 6
" 10. Astacus (Cambaroides) Japonicus Fax. . . . . × 8
" 10′. The same. . . . . × 8

* The distinction between form I. and form II. is not well shown in these figures. Compare the description on page 124.



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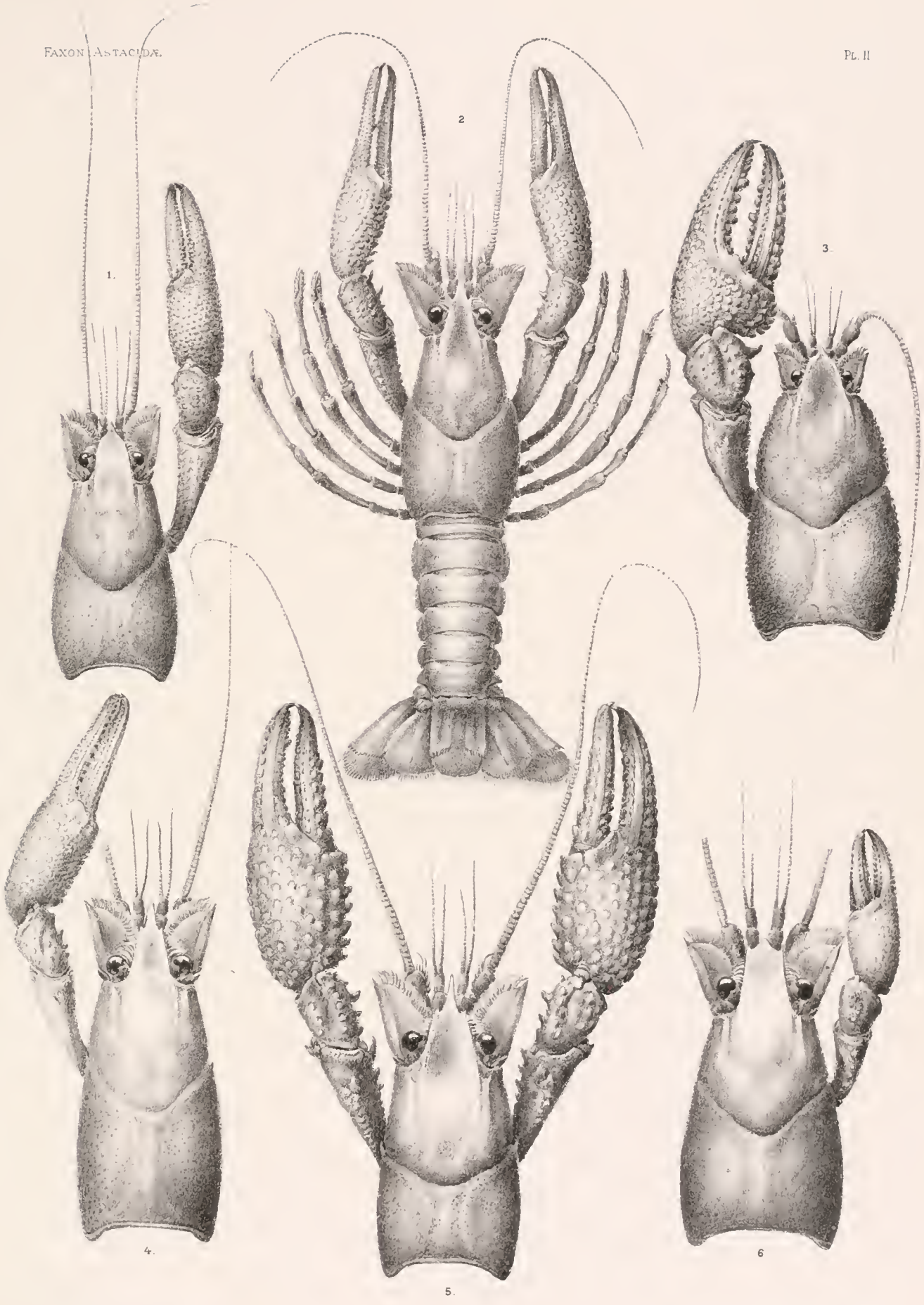
5. C. IMMUNIS, VAR. SPINIROSTRIS.



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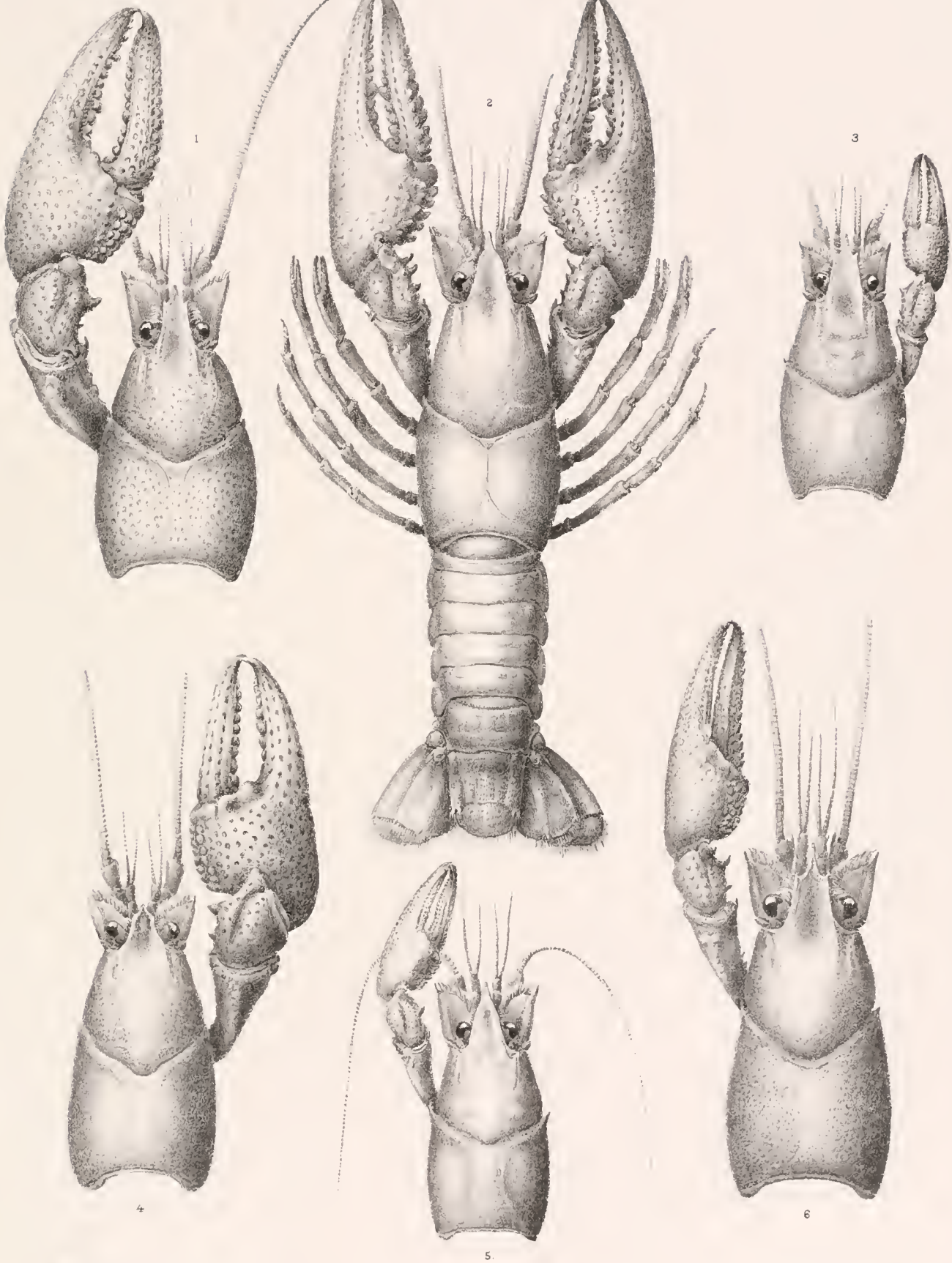
5. C SPICULIFER. 6. C MONTEZUMÆ, VAR TRIDENS



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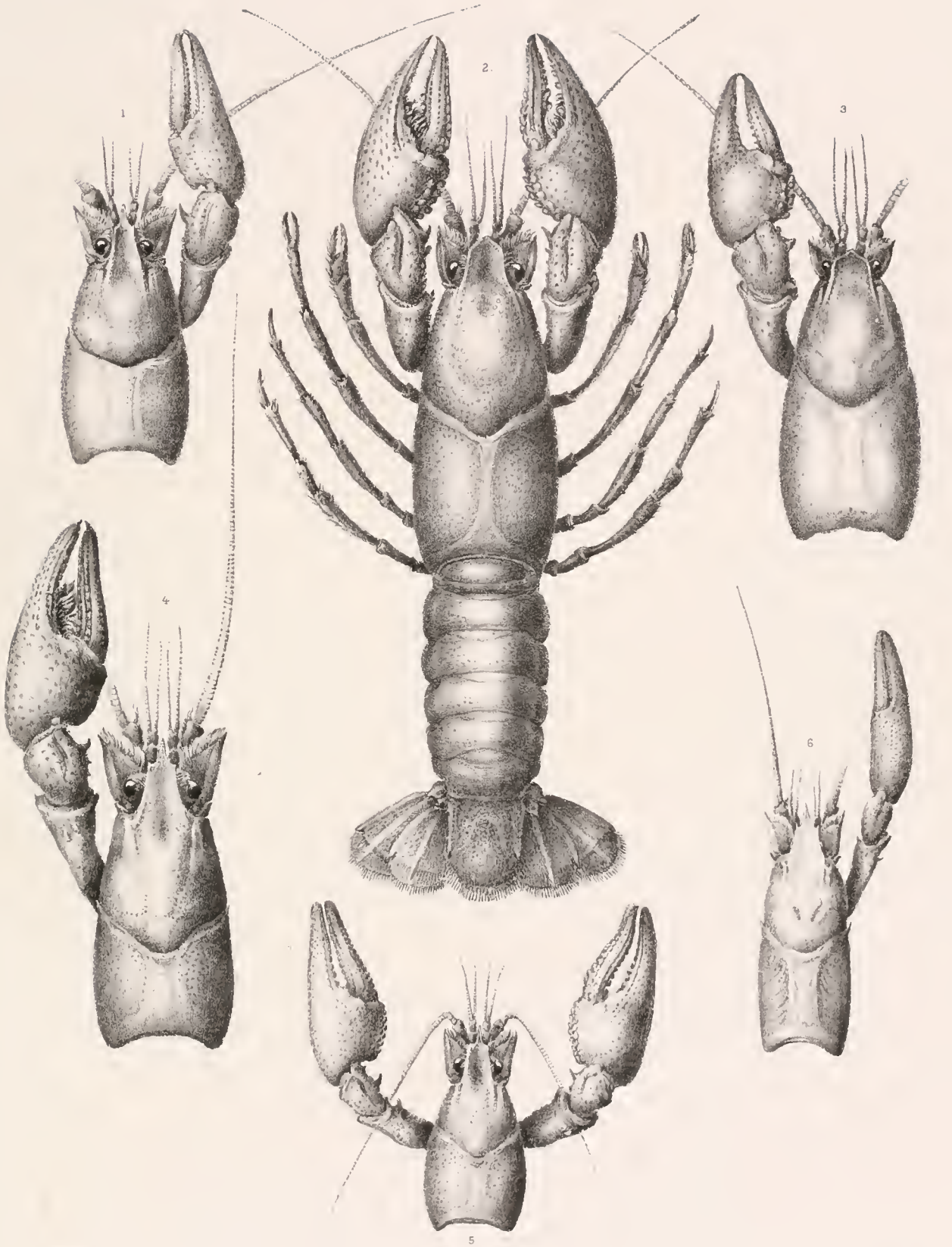
1. C. HARRISONII. 2 C. MISSISSIPPIENSIS. 3 C JORDANI. 4. C MEDIUS
5 C ACUMINATUS. 6. C. PALMERI



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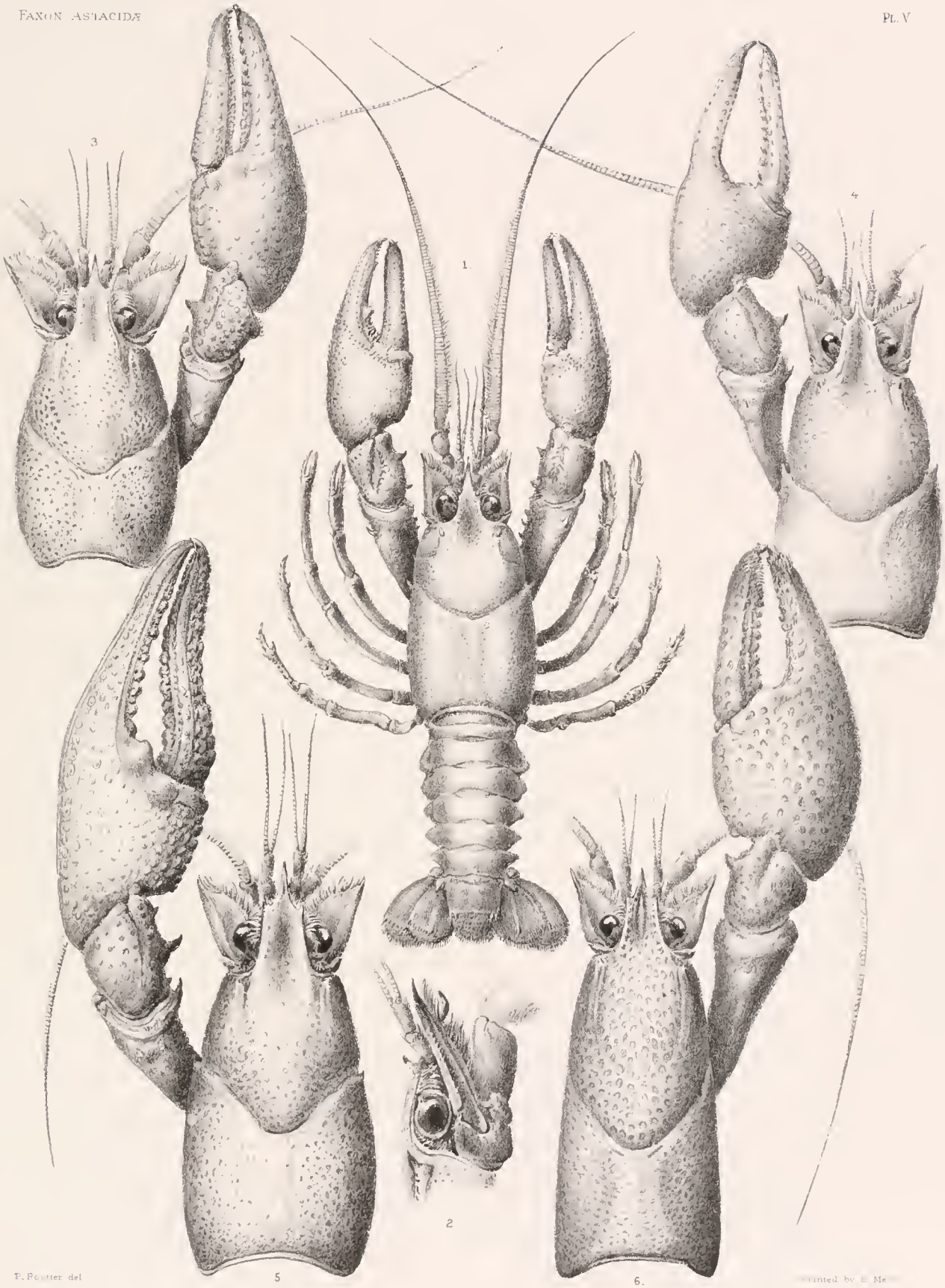
1. C. GIRARDIANUS 2. C. ARGILLICOLA 3. C. DUBIUS 4. C. ALABAMENSIS
5. C. SUOANII 6. C. HAMULATUS



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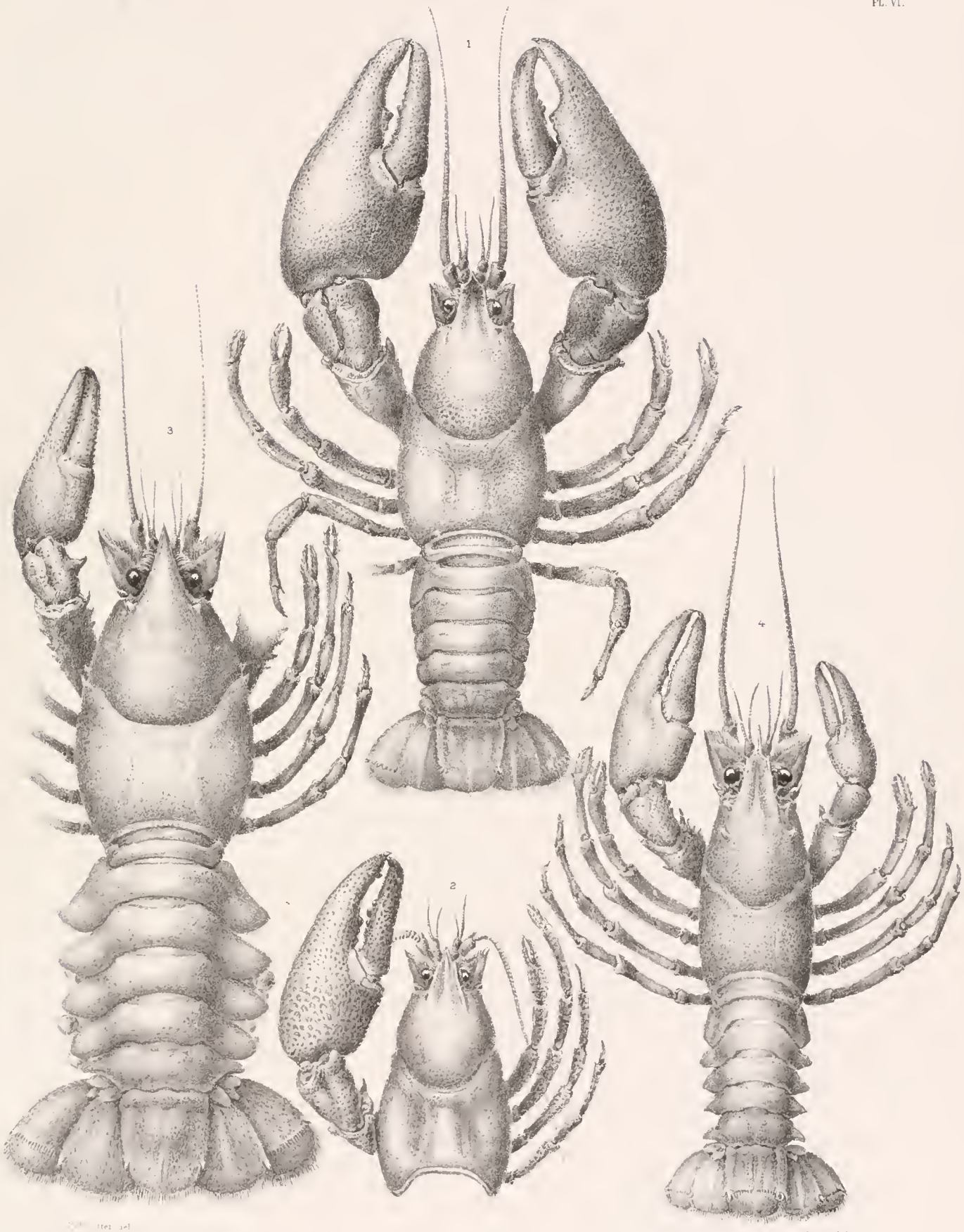
1. 2. C. CORNUTUS. 3. C. PROPINQUUS, VAR. SANBORNII. 4. C. FORCEPS.
5. C. PUTNAMI. 6. C. COMPRESSUS.



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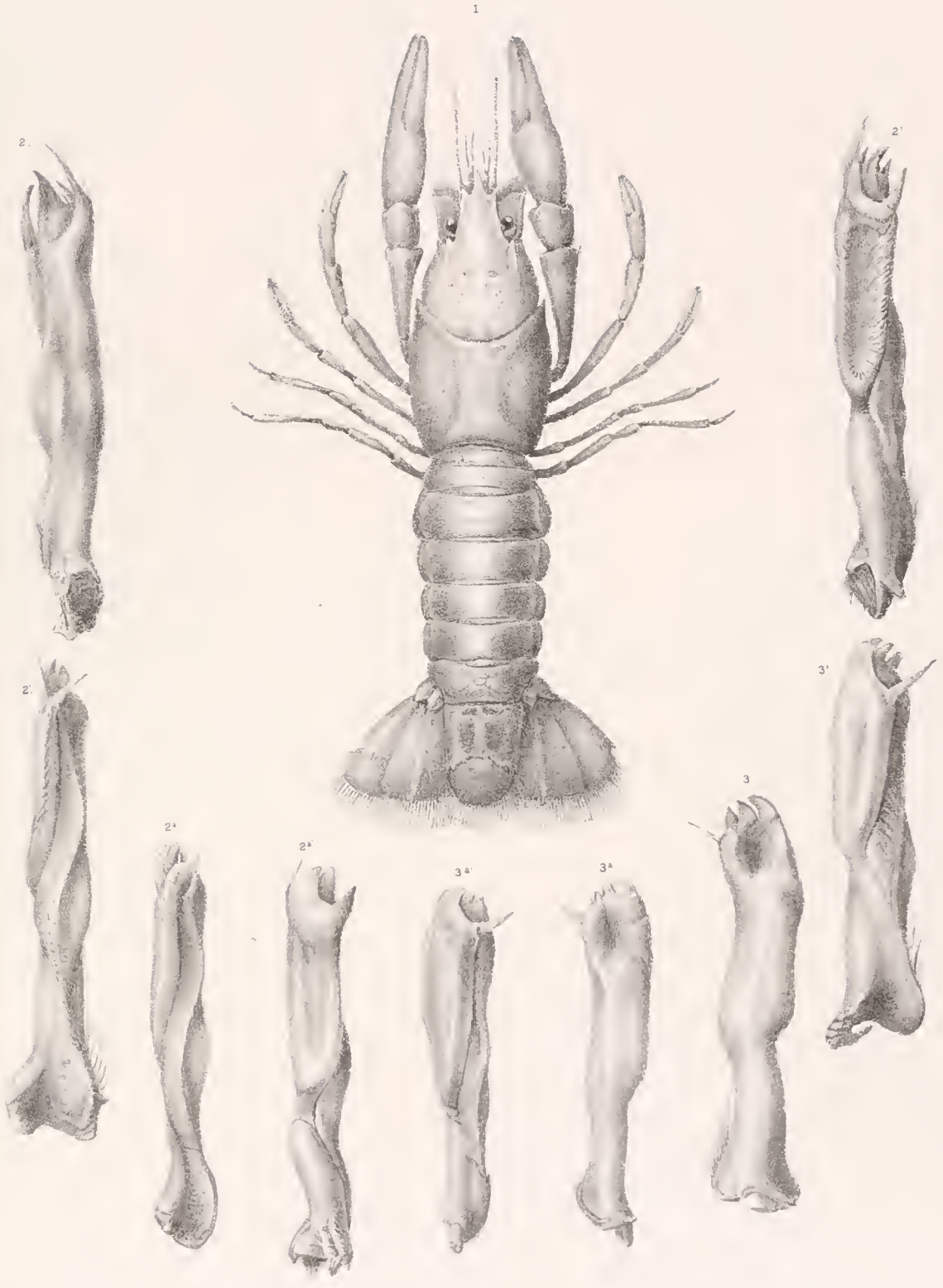

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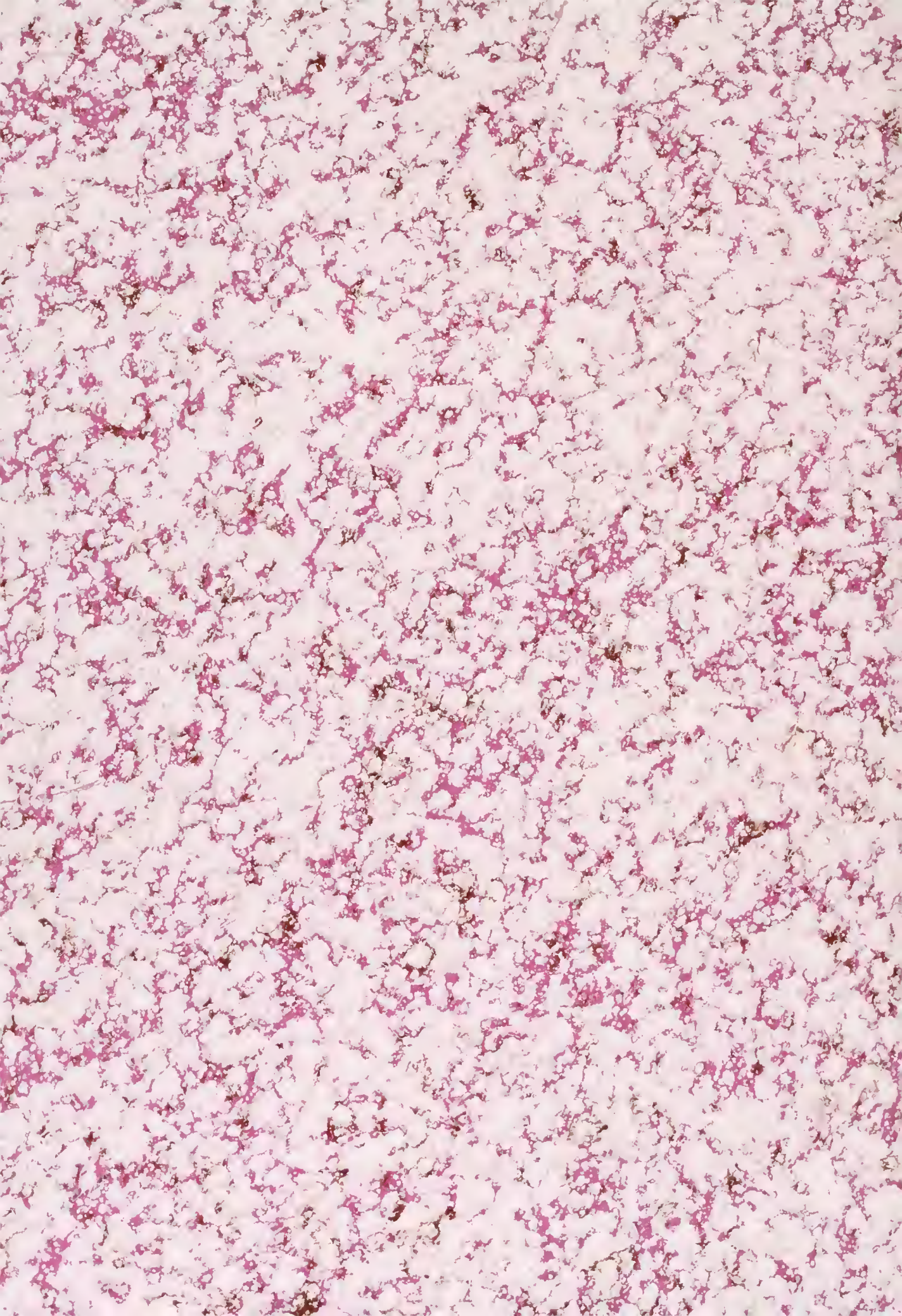

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